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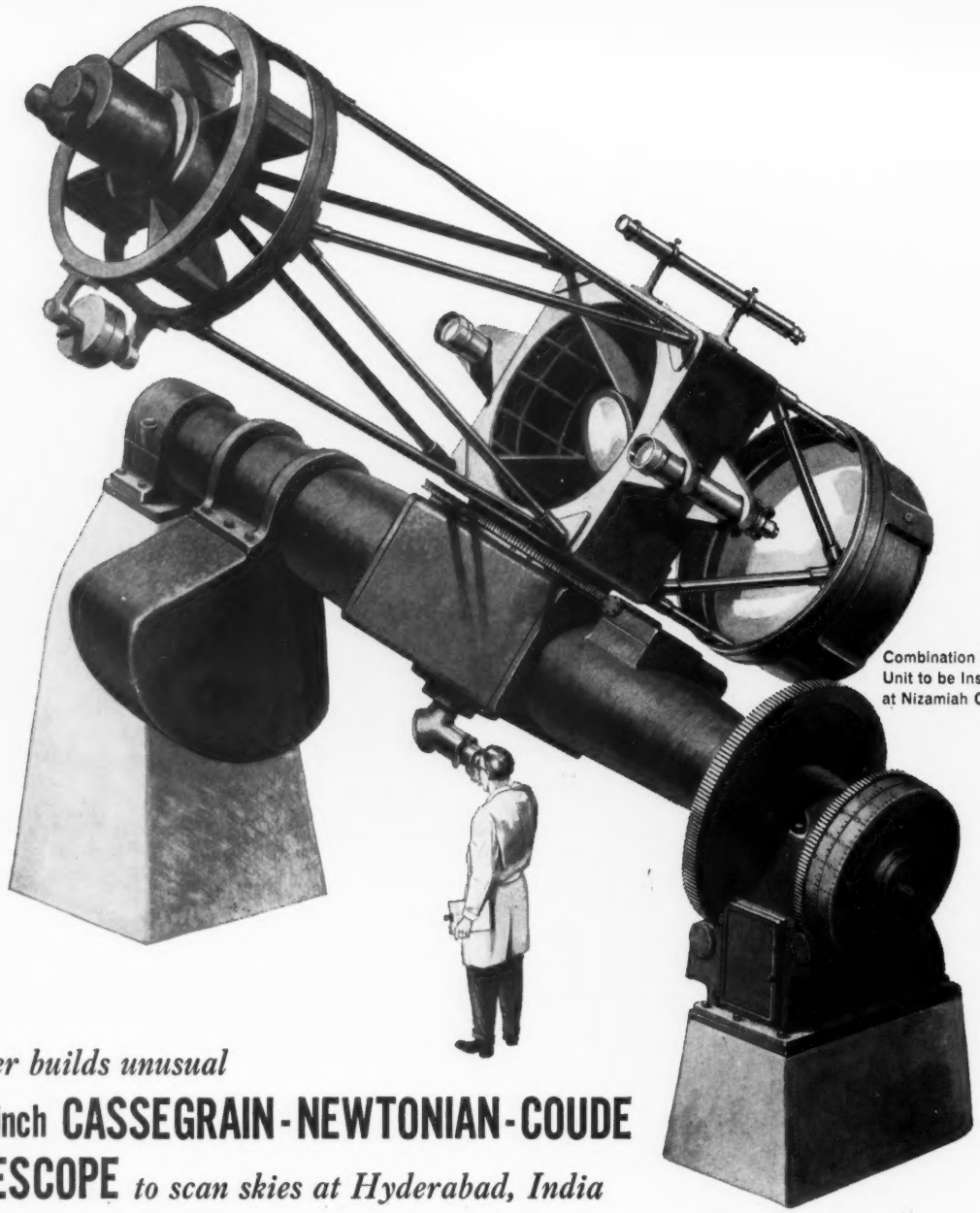

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Sky and TELESCOPE

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Vol. XVIII, No. 10 AUGUST, 1959

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FRONT COVER: Philip J. Del Vecchio, of Paterson, New Jersey, seated at the controls of his transistorized radio receiver for detecting atmospheric noise. His son Robert is adjusting the radio-frequency oscillator that tunes the receiver. They use this apparatus to detect sudden enhancements of atmospherics (SEA's) — sharp rises in radio static indicating flares on the sun. Photograph by Richard Gigli of the Paterson "Evening News." (See page 546.)

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New S & T Headquarters

IN JUNE, the general offices of SKY AND TELESCOPE were transferred to 49-50-51 Bay State Road, in Cambridge, Massachusetts, about two-thirds of a mile from Harvard Observatory. The new quarters, three buildings in all, afford facilities for the entire business operation of Sky Publishing Corporation. One of these was erected three years ago and has been in use since that time.

Although we are no longer within the physical environment of the observatory, the scientific and literary association of nearly 18 years will continue unchanged, to the great benefit of the readers of this magazine and other Sky publications. Their acceptance and growth, and this final "going on our own" are due in very large measure to the continued support of Harvard University in providing ever-increasing office space, and to the personal advice and encouragement of Harvard astronomers, especially two of the observatory's directors.

It was on the initiative of Dr. Harlow Shapley and his successor, Dr. Donald H. Menzel, that in October, 1941, *Sky* magazine was moved from the Hayden Planetarium in New York City to combine with the *Telescope*. Since then, several research associates of the observatory have been active members of our editorial department's staff.

Through the years our space requirements increased, while the observatory was also expanding its scientific programs. In 1954 our commercial operations were moved to a nearby location, and in June, 1956, the editorial staff occupied quarters in Kittredge Hall, where the Smithsonian Astrophysical Observatory's Moonwatch program was established. Now, with our personnel numbering nearly 20, it has become essential to consolidate our working areas to secure economies of time and convenience.

Harvard College Observatory is still our mailing address and point of publication. As always, astronomers from everywhere are welcome to visit us — on Bay State Road in West Cambridge.

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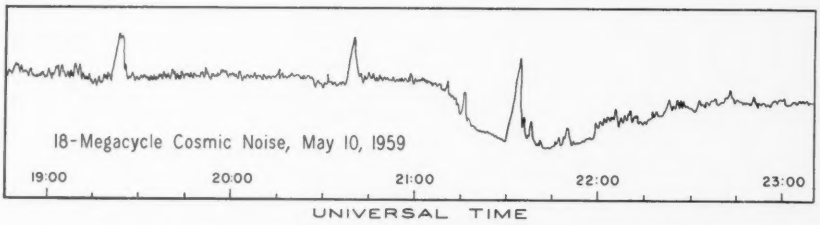
THE SOLAR FLARE OF MAY 10, 1959

ON MAY 10th this year, at 21:02 Universal time, a flare of importance 3+ burst forth on the sun. This was almost precisely — even to the hour — 10 years after a very similar event had occurred (SKY AND TELESCOPE, October, 1949, page 307).

A flare and its associated ionospheric disturbances are, at present, classified by importance, 1— being the least and 3+ the greatest. The typical flare of importance 3, for example, has a wider, more intense hydrogen-alpha line than do flares of importance 1 or 2; it covers about a thousandth of the sun's visible hemisphere and lasts for over an hour. Thus, the flare of May 10th ranks as one of the largest and brightest yet observed.

The spectroheliograms show that the flare took place in the vicinity of a spot group on the northeast quadrant of the sun, fairly near the limb. According to High Altitude Observatory's preliminary report, one peak of maximum intensity was reached at 21:18, another at 21:40. B. C. Parmenter of Spokane, Washington, reports that flares were still evident the following day. By May 12th, the whole region of the spot group exhibited exceptionally bright flocculi and, toward the limb, one or two small flares had arisen.



A pronounced SCNA (sudden cosmic noise absorption) is a wide dip on this tracing of 18-megacycle extraterrestrial radio noise on May 10th. Short sharp peaks are bursts of solar origin. McMath-Hulbert Observatory diagram.

Simultaneously with the appearance of the flare, there began a sudden enhancement of atmospherics (SEA), reported as importance 2 by the High Altitude Observatory and as 3+ at Paterson, New Jersey (page 547); there was also a sudden cosmic noise absorption (SCNA). Both of these events lasted until after 24:00.

The great flare of May 10th was photographed in red light of hydrogen at 23:00 UT by B. C. Parmenter, Spokane, Washington. He used his 14-foot spectroheliograph, which gives a solar image 83 millimeters across. The exposure was made through a break in clouds.

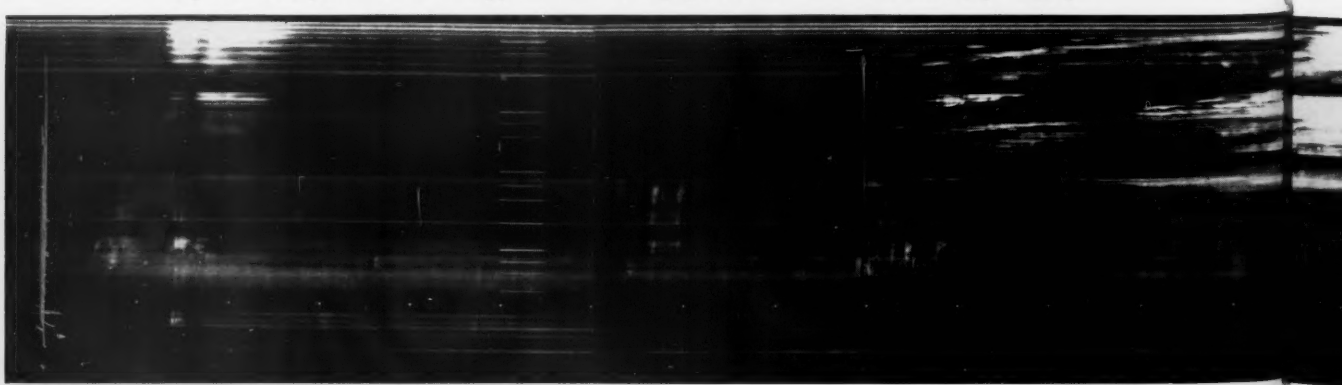
The SCNA record reproduced at the top of this page was furnished by Dr. Helen Dodson Prince, McMath-Hulbert Observatory. There is evidence of flare activity taking place before the major outburst. As the tracing shows, the level of cosmic radio noise was steady until 19:25, when it was interrupted by a sudden rise due to solar noise produced by a flare. At 20:40 another flare appeared, while shortly after 21:00, due to the increased absorptivity of the ionosphere triggered by the large, bright flare and other activity, cosmic noise absorption began.

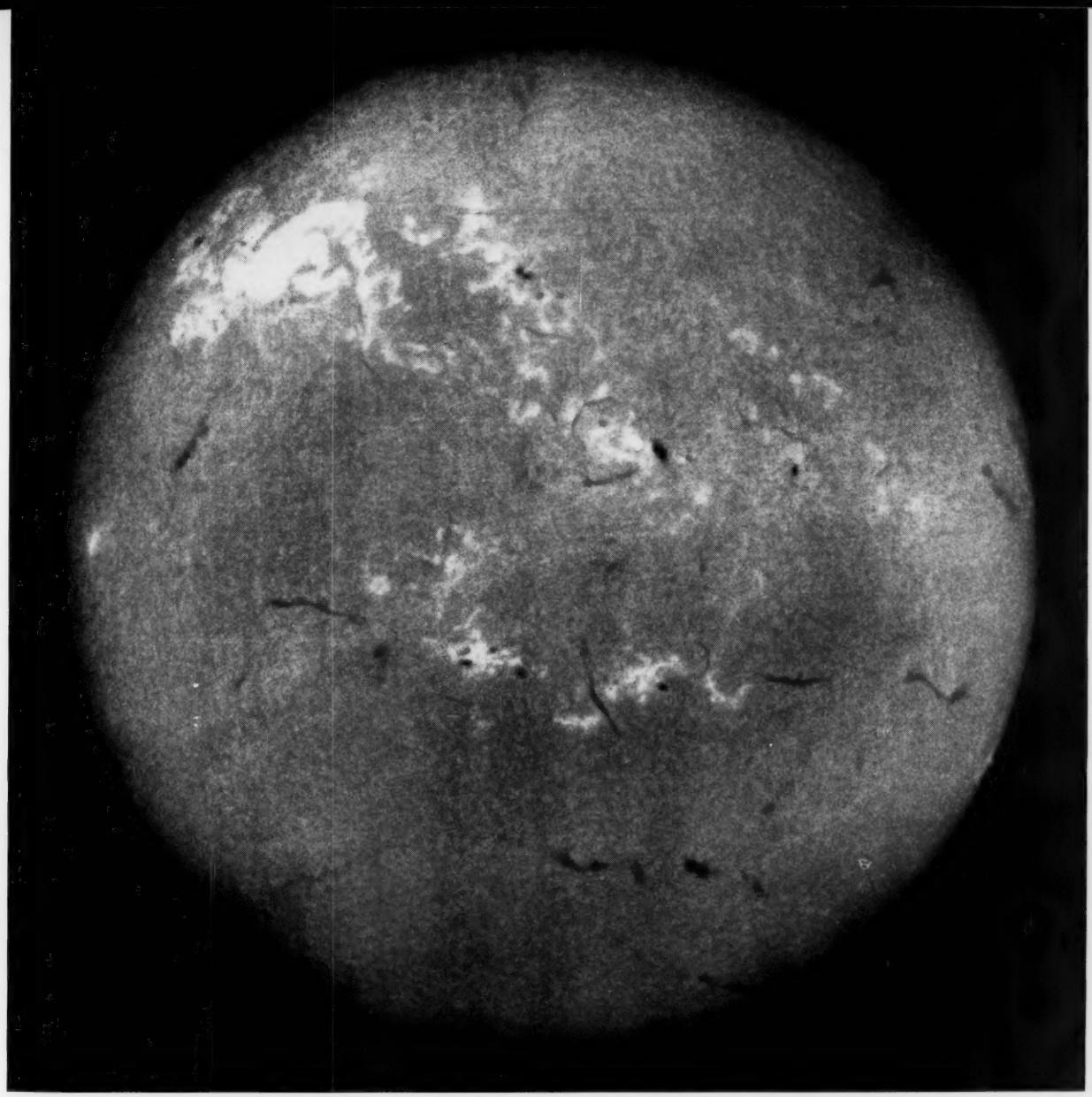
These three flare events and their accompanying ionospheric effects were also detected at the McMath-Hulbert Observatory by equipment monitoring the intensity of the 5-megacycle-per-second signal from radio station WWV. In each case, the signal faded at the times indicated above. According to the High Altitude Observatory report, a slow short-wave fadeout of importance 3+ began at 21:10.

Major bursts of solar radio noise at various frequencies began around 21:15 and lasted to 23:02. At the bottom of this page and the facing one is a sequence of radio observations made by Alan Maxwell at Harvard Observatory's radio astronomy station in Texas. A strong group of fast-drift bursts at about 21:16 was followed by some weaker ones between 21:21 and 21:25, when a slow-drift burst began. Then, for the next 20 minutes, continuum radiation of moderate intensity gradually built up in the frequency band 100 to 300 megacycles per second. Fairly often these various types of bursts appear in this order. About 65 per cent of all slow-drift bursts are preceded by a group of fast ones, while around 12 per cent are accompanied by continuum radiation.

The interval of approximately seven minutes between the fast- and slow-drift

This record of radio bursts was obtained on May 10th at the Harvard Radio Astronomy Station in Texas. Evenly spaced white dots are minute marks, from 21:15 UT at the left to 21:43 at the right on the facing page. High levels in the sun's atmosphere are represented in the upper sections (see page 556). Harvard Observatory photograph.



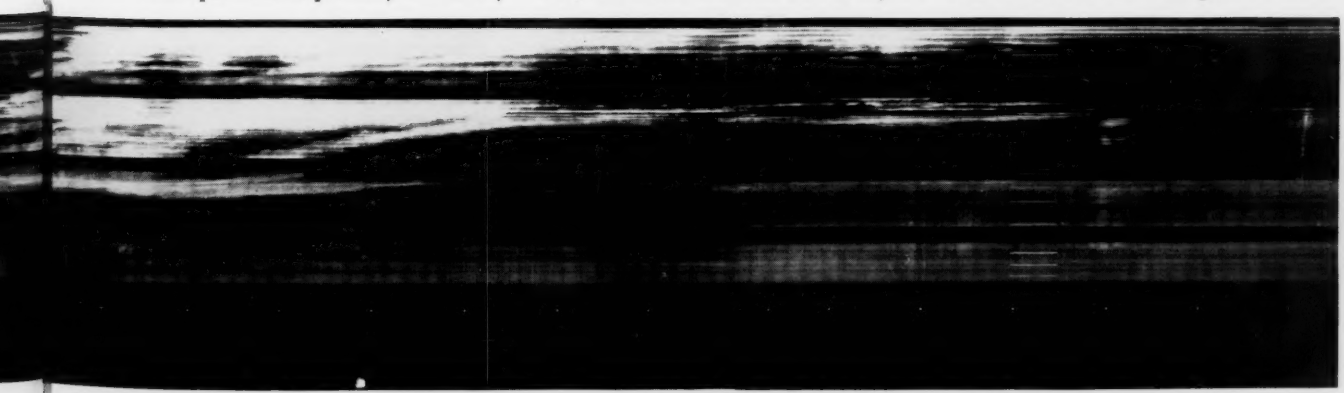


In a monochromatic picture, taken at Sacramento Peak Observatory in New Mexico, the flare region is large and bright (upper left). Compare this view with the direct photograph on page 546, which is oriented somewhat differently.

bursts observed on May 10th is close to the delay predicted on the basis of separate disturbances traveling at different velocities outward through the sun's atmosphere.

Other phenomena probably induced by this gigantic flare included the abrupt commencement of a magnetic storm at 23:18 on May 11th; this event ended at 1:00 on the 13th. There was an intense auroral display in the evening on May 11th, and an increase in cosmic ray activity was detected at the University of Minnesota the following day.

This great solar disturbance, one of the largest and best-observed in recent years, should add much to our knowledge of solar-terrestrial relationships.



Indirect Detection of Solar Flares

PHILIP J. DEL VECCHIO

ERUPTION of a major flare on the surface of the sun is one of the most dramatic sights in astronomy. No less exciting — and more easily observed with equipment of modest cost — is the electronic signature of such a giant eruption traced by a moving pen recording ionospheric phenomena triggered by the flare.

In 1937, R. Bureau was using a receiver tuned to 27 kilocycles per second to study *atmospherics*, mainly radio noise originating in distant thunderstorms and reflected from the ionosphere. During this work, he recorded sudden increases in noise strength that were coincident with outbreaks of major flares. Since then, a number of professional observatories have been operating similar equipment on frequencies between 20 and 30 kilocycles per second.

Such a sudden enhancement of atmospherics, or SEA, has become an important indirect indicator of solar flares. Since the fall of 1956, some amateur astronomers have been using simple transistorized radio receivers on 27 kilocycles, and now a network of eight stations from New York to California reports SEA's to the National Bureau of Standards. Events that involve widespread solar-terrestrial phenomena are published, along with the reports of professional observatories, in the bureau's *CRPL-F, Part B* series, *Solar-Geophysical Data*.

The simplified receiver, using three transistors, can be built by almost anyone at a cost of $20 to $30, depending on the quality of the components used. But to make a permanent, legible record, the output of the receiver must be fed into some kind of pen recorder, and even second-hand ones cost from $100 to $500. An advanced amateur may be able to borrow a suitable recorder from one of the many industrial firms now using them.

Since most radio communications employ relatively high frequencies, very few stations operate at or near 27 kilocycles. Consequently, a receiver tuned to this frequency will generally pick up only atmospherics generated by thunderstorms. If the output is then smoothed by including an integrating capacitor in the circuit, the recording instrument will trace the atmospherics' average intensity.

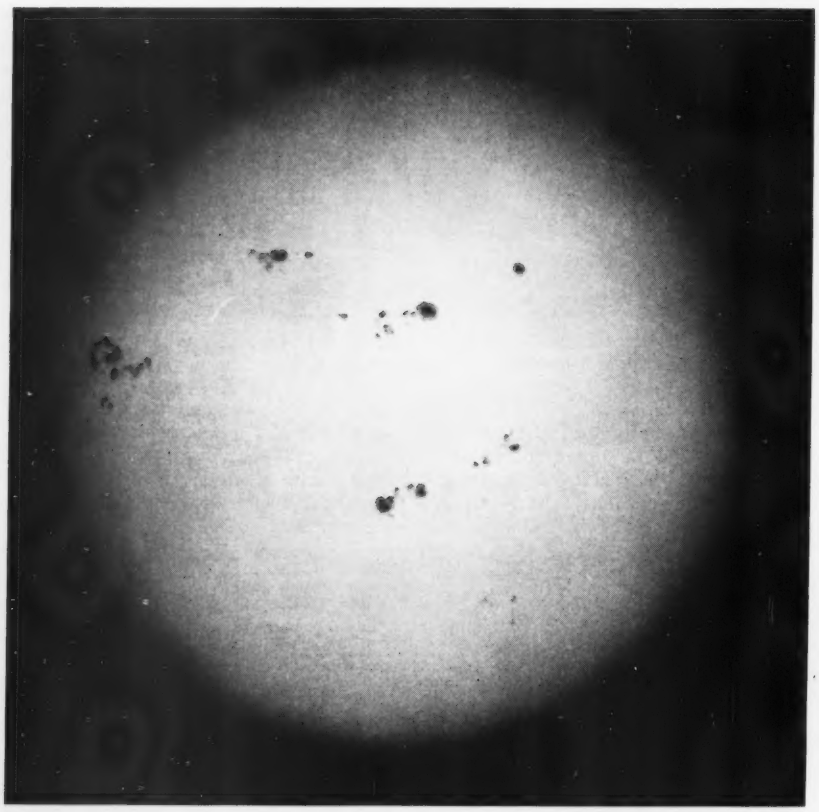
The trace will be high and disturbed at night, when the far-distant noise is propagated by reflections from the E layer of the ionosphere, and occasionally from sporadic clouds. At sunrise, when the sun's rays ionize the lower ionosphere, the D layer forms at a height of about 50 miles. Thereupon the signal drops considerably from the nighttime level, as a result of absorption and multiple reflections, but remains remarkably constant throughout the daylight hours.

If a solar flare of considerable magnitude occurs while the observing station is in the sunlit hemisphere, that station is likely to experience a sudden increase in the signal strength — an SEA. This had been thought to be due to a change in ionization of the D layer, but, recently, instrumented rockets have demonstrated instead that a new ionized reflecting layer forms directly below the D layer, to a depth of perhaps 12 miles. It is this layer that brings about the increased signal level.

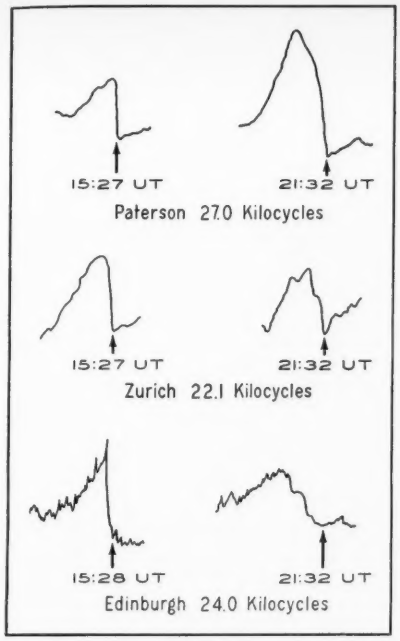
As the solar flare and its associated soft X-ray emission subside, the newly formed layer dissipates by recombination of the ions and electrons. The recorder pen then begins a slow fall back to normal as the atmospherics decrease in strength.

The shape or pattern of the SEA will depend on the integrating capacitor incorporated in the receiver, and on the sensitivity and response of the recorder. Records may be affected by low- or high-level interference from brush-type motors, power-line leaks, local thunderstorms, and other factors.

The basic pattern of recorded atmospherics interrupted by an SEA can be seen in the drawing reproduced at the bottom of page 547. The sunrise drop, a characteristic phenomenon, begins a few minutes before local sea-level sunrise at the observing station. This fall sometimes amounts to the entire width of the recording chart. The small dip and the following precursor peak are peculiarities of the pre-sunrise pattern that are still being investigated. In a personal communication, Dr. M. A. Ellison of Dunsink Observatory says that propagation seems to take place through a "leaky wave guide," the earth being a perfect conductor and the ionosphere an imperfect one, and that interference effects set in when the reflecting ceiling begins to fall.



The author's son, Robert Del Vecchio, took this solar photograph at Paterson, New Jersey, on May 10, 1959, at 20:03 Universal time, with a 2.4-inch Unitron refractor. The exposure was 1/1,500 second, through a blue-green filter. At the left edge (east) is the large sunspot group where a major flare began about an hour later (see page 544).



Two SEA's recorded on July 30, 1958, at monitoring stations in New Jersey, Switzerland, and Scotland. Time on each of these six tracings progresses from right to left.

Characteristics of SEA Traces

Recordings of the same SEA can be quite similar even though obtained at observing stations thousands of miles apart. Compare the flare-produced SEA as recorded by me at Paterson, New Jersey, on July 30th last year, with the record of Dr. M. Waldmeier at Zurich, Switzerland, and the trace by Dr. Ellison (then at Edinburgh, Scotland), using a sensitive receiver with a fast response. At least six observatories reported a flare of importance 2+ between 15:23 and 15:29 that day, while four amateur and seven professional stations recorded the SEA.

While it is generally believed that ionospheric effects of solar flares are experienced only in the earth's sunlit hemisphere, evidence is piling up that this is not always the case. King and Sullivan have noted that SEA's do occur when the observing station is in darkness. The top right trace of the July 30, 1958, flares, beginning at 21:32 Universal time, was made in the afternoon at Paterson, but it was after sunset at Zurich and Edinburgh. Yet these latter traces are plainly SEA's, although distorted in form. Three amateur and three professional stations recorded this SEA, while the flare was being observed at Honolulu, Hawaii, and Sacramento Peak, New Mexico, at 21:38 and 21:39, respectively.

Several other methods are used to detect solar flares by means of ionospheric disturbances. The most important are SCNA, sudden cosmic noise absorption; SSWF, sudden short-wave fading; and SPA, sudden phase anomaly.

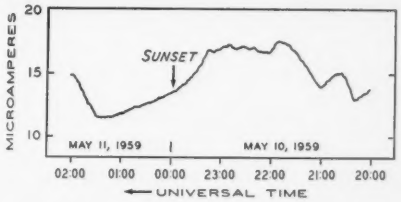
The SCNA method records galactic or cosmic noise coming to us from space. It is partially absorbed as it passes through the ionosphere, but when a flare occurs the absorption increases suddenly. The July 30, 1958, flares were accompanied by SCNA's recorded at the McMath-Hulbert Observatory and reproduced below. It can be seen that the typical SCNA pattern is very nearly the mirror image of an SEA: The former drops off rapidly and recovers slowly, whereas the SEA rises quickly and fades slowly.

Regarding the relative reliability of these different methods, Robert H. Lee, of the High Altitude Observatory, points out that SCNA gives very few false flare indications, but that it may miss some flares that the SEA system detects. This is especially true in the winter, when SEA's are pronounced and SCNA's less intense.

McMath-Hulbert astronomer Helen Dodson Prince notes, "We must always remember that the 18-megacycle-per-second SCNA is often the resultant of two things, increased ionospheric absorption and increased solar emission at that frequency. The latter may not occur, but it does sometimes, and it makes the analysis of the 18-megacycle data exceedingly difficult."

Sudden short-wave fading, indicating a solar flare, is experienced in long-distance, high-frequency radio transmission channels. The station signal fades out abruptly, and slowly returns to normal. There are also slow fadeout and gradual fadeout phenomena, which are somewhat less definite than the SSWF.

SPA's, or sudden phase anomalies in long-wave transmissions, can be obtained by recording the phase difference between the ground wave and the reflected ionospheric wave from a nearby transmitter. In another technique, a single receiver is used to measure the resultant amplitude of the ground wave and the ionospheric wave.

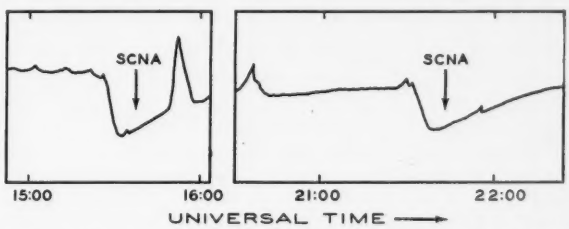


The May 10, 1959, Paterson record shows two SEA's (right), the second one so long-lasting as to obliterate the normal sunset rise (see basic pattern at bottom of this page).

The SEA of May 10, 1959

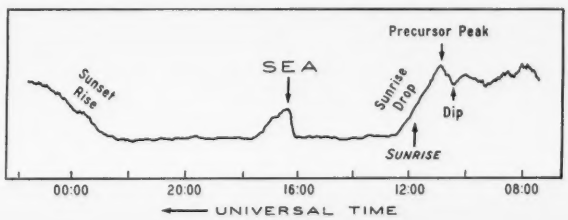
The record just above is a copy of our 27-kilocycle tracing of atmospherics on the day of the great solar flare of May 10th (see pages 544-5). A smaller, incomplete SEA began at about 20:23 UT, reached a maximum about 20:37, and was still decreasing at 21:02, when the major SEA of the day became superimposed on the record.

Of importance 3+, this SEA reached its maximum at about 21:52, but maintained a high level of activity for nearly three hours (very unusual behavior). On normal days, the average atmospherics curve shows a drop to sunset and then begins a post-sunset climb. The chart shows that the activity of this SEA decreased slowly to about 1:30 UT on the 11th, delaying the sunset rise until that time. The SEA reported by the High Altitude Observatory in its preliminary report TR-402 began at 21:02 and lasted until after 24:00.



Two sudden cosmic noise absorptions appear on this 18-megacycle record of July 30, 1958, made at McMath-Hulbert Observatory, Pontiac, Michigan.

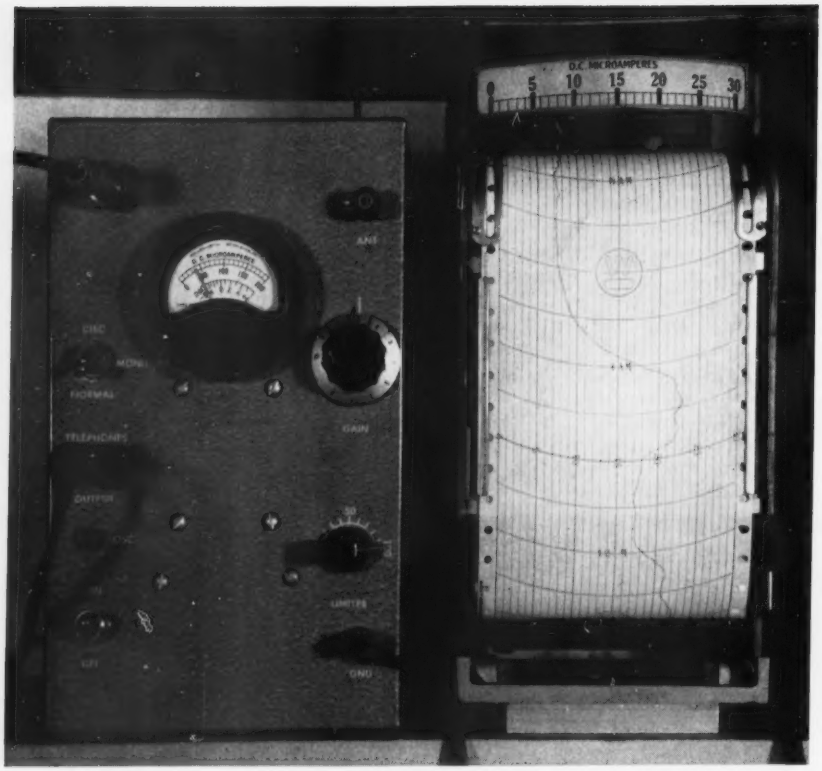
My son Robert took the photograph of the sun in white light at 20:03 on May 10th, using a camera of our own design attached to a Unitron 2.4-inch refractor. The major sunspot group, in the area where the flare occurred, was reported by the U. S. Naval Observatory as covering a total area of 1,600 millionths of the sun's visible hemisphere on May 9th (preliminary measurement), and by the 11th the region had grown to 2,471 millionths and involved 18 sunspots.



The basic daily pattern of atmospherics at 27 kilocycles per second is illustrated here. It is interrupted by an SEA commencing near 16:00.

The Atmospherics Receiver

The equipment we use for recording SEA's is on the next page and the front cover. It is not recommended that commercially available receivers be used for this work, especially if they use alternating current, which is subject to constant fluctuations. Our receiver is essentially of



Philip J. Del Vecchio's 27-kilocycle receiver for detecting atmospherics, and pen recorder (right). This equipment can be seen also in the front-cover picture of the interior of his astronomy laboratory. The receiver circuit is shown in the diagram on this page.

the type designed by David Warshaw, of Brooklyn, New York, and cost only $18. It is very stable, using transistors and powered by D dry cells. The drain on the batteries is so slight that they last almost as long as they would on the shelf. No replacements of components or batteries have been made for 1½ years.

The changes we made in Warshaw's design were to provide optimum performance at this station. Resistances were changed in various parts of the circuit, and a 0.01 microfarad fixed capacitor in the first stage was used instead of Warshaw's 0.001 capacitor. As the circuit diagram shows, in the last stage is a 1,000-microfarad electrolytic capacitor, which serves to smooth the atmospherics trace. There is a switch for cutting this out, so that individual pulses can be recorded.

If a commercial receiver must be used, the last stage will have to be modified to average the pulses in the same manner. War-surplus stores in large cities may have such receivers as the Navy model DZ-2, which was designed to be used in aircraft as a direction finder and tunes from 15 to 70 kilocycles, as well as from 100 to 1,750 kilocycles, making it quite a versatile receiver. It is available with a loop antenna, which is desirable in the event of interference.

The recorder must be of the direct-current type, with a range on the chart of about 100 microamperes. Prices run from about $360 for an Esterline-Angus to about $1,500 for a General Electric. Our own Westinghouse recorder was obtained from the Bell Telephone Laboratories.

Antenna Characteristics

Because of the relatively low operating frequency, 27 kilocycles per second, antenna design is not too critical. A quarter-wave antenna, such as is often used at higher frequencies, would be much too long for the average amateur to install.

In order to obtain maximum efficiency with the circuit using the 6324 Miller coil for a primary, the best antenna is about 30 to 50 feet high and about 100 feet long, including the lead-in portion. However, because of interference at our location, our 100-foot antenna is as far away from existing structures as possible, 30 feet above the ground.

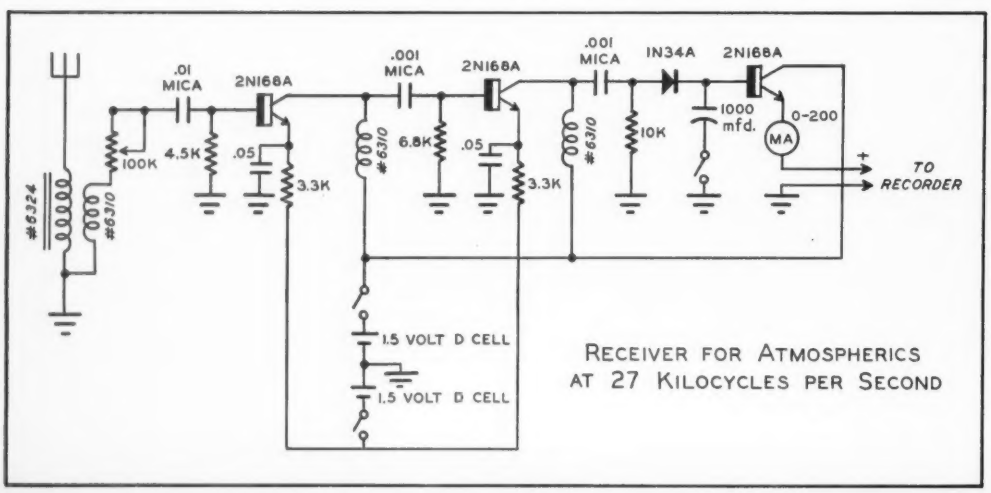
The transmission line from the antenna to the receiver is a 100-foot length of Belden RG-58AU coaxial cable. This serves to ground most of the interference from neighboring houses. The primary antenna coil has been changed to Ram's 201R-10.

Auxiliary Equipment

The front-cover picture of part of our astronomy laboratory shows the main and auxiliary equipment we use in the atmospherics and many other solar projects. My hand is on the switch of a pilot 27-kilocycle receiver, which is wired to the Dumont oscilloscope in the lower right. We use this separate pilot to monitor the incoming signal, examining it visually on the oscilloscope to analyze extraneous interference.

The main receiver is to the left of the pilot, while the Westinghouse microammeter chart recorder is to the right. At

(Continued on page 551)



This circuit diagram of the SEA detector built by Mr. Del Vecchio is based on the design of David Warshaw. Coils are labeled by their Miller numbers; resistances are in thousands of ohms (K ohms); capacitances are in microfarads. The 1,000-mfd. capacitor is a 6-volt electrolytic one. The 100K potentiometer controls the receiver gain. See "Radio-Electronics," January, 1959, page 41, for the diagram of another version of this circuit, with useful construction details.

Some Perseid Meteor Spectra of the Past Decade

JOHN A. RUSSELL, *University of Southern California*

EACH AUGUST, with near-perfect regularity, the Perseid meteor shower occurs. One of the oldest and best-known of visible meteoric events, this was the first shower whose orbit was shown, by G. V. Schiaparelli in 1866, to be similar to that of a known comet – 1861 I. It was also the first shower for which a night-to-night motion of the radiant was detected.

Observations of these meteors have been traced back 1,200 years. The recurrence of the Perseids over so many centuries is due in part to the large, 65-degree angle of inclination between the orbital plane of the particles and the ecliptic. This minimizes the perturbing effects of Jupiter and Saturn, as those planets and the swarm are kept well separated.

Systematic study of the Perseids was begun during the decade 1830-40, when the periodicity of the shower was established. At the height of the display, around August 11th every year, a favorably located observer can generally see about 50 meteors per hour. Although for more than a century Perseids have never failed to appear, in 1911-12 the maximum count dropped to only five or six per hour, leading some astronomers to wonder if the shower might be disappearing. However, a decade later the maximum rate rose to over 200 per hour.

My interest in the Perseids, originally stimulated by reading about meteor spectra in Fletcher Watson's book, *Between the Planets*, goes back to 1947. While the types of spectra seemed to correspond qualitatively to types of recovered meteorites, there were serious quantitative discrepancies. Moreover, I was intrigued by the simplicity of the minimum equipment with which meteor spectra could be photographed, success appearing to depend more on patience than on brains or money! Therefore, in 1948 I decided to take a camera, tripod, and prism (Fig. 1) along on my annual summer vacation in the Sierras and see what might come of a few nights observation.

Fig. 1. This folding camera, fitted with an objective prism, was the simple equipment used by the author to obtain the meteor spectrum in Fig. 3.

Fig. 2. To the west of this vantage point overlooking the Feather River, the author photographs meteors on his summer vacations. The location is a mile above sea level, in the Sierra Nevada range near Blairsden, California.

The observing site is 1,000 feet above the valley floor of the Feather River near Blairsden, in the Plumas Forest district of northeastern California (Fig. 2). This area is remarkably free from wind and the sky is very clear; more meteor spectra have now been photographed there than at any other place in the United States.

In 1948, meteoric spectroscopy was still a relatively new field. Prior to 1931, only eight meteor spectra had been photographed, all accidentally in the course of other observations. Then Peter M. Millman in Canada added a ninth spectrum and began his classical study of the subject. He found that meteor spectra, all of them of the emission type, could be divided into two classes: *Y*, with the H and K lines of ionized calcium the predominant feature; and *Z*, with these lines absent. Iron lines, of which *Z* spectra are largely composed, are numerous in practically all meteor spectra.

One spectrum, in which the H and K lines were present but not dominant, Millman tentatively called *X*, pending discovery of more spectra of this or other types. At that time, all known spectra of shower meteors were of type *Y*, while sporadic meteors were divided about evenly between *Y* and *Z*.

By 1948, the number of spectra obtained was approaching 100, having been augmented by 26 from the great Giacobinid shower of 1946. The Giacobinids, incidentally, were the first shower meteors of type *Z*. Their velocities are very low; hence the absence of H and K lines was explained as the result of a lack of sufficient energy for ionizing calcium atoms.

A spectrum of a Perseid, obtained during my first year of observation, is shown in Fig. 3. Like all reproductions of spectra in this article, the direction of motion of the meteor is downward, and the violet end of the spectrum is at the left. This meteor's radiation exhibited the characteristics of all three types of spectra. In the early stages the H and K lines were not visible; later they appeared, though less intense than some other lines; and in the final stages they dominated the spectrum. Evidently the presence or absence of ionized calcium lines is not necessarily the result of differences in the quantity of that element. The lines were absent from the first part of the spectrum because there was insufficient energy for their production.

A second unusual feature of this same Perseid spectrum is the number of bursts or flashes in the final stage. These seem

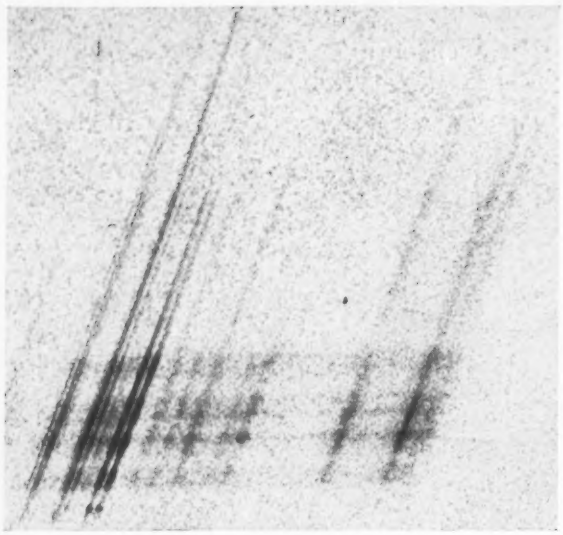


Fig. 3 (left). The two strongest lines in this Perseid spectrum are H and K of ionized calcium. Note how their lower ends remain bright while most other lines become invisible. The strong line at the right is D, of sodium.

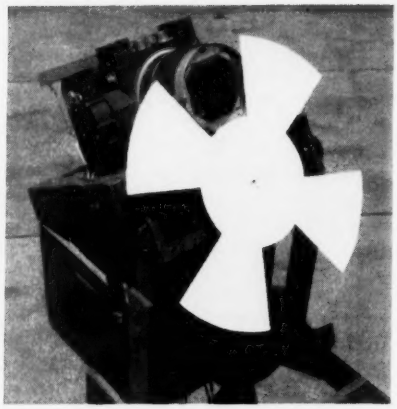


Fig. 4 (right). The rotating shutter on an improved meteor spectrograph, used from 1951 on. All photographs with this article are by the author. The spectra are reproduced as negatives, the emission lines appearing dark.

to occur chiefly in bright meteors. John S. Rinehart and his associates, then at the Naval Ordnance Test Station, China Lake, California, from controlled experiments found evidence that rapid bursts are a result of fragmentation.

By 1951 our equipment included a large 25-degree prism of very dense flint glass, measuring 4½ inches on an edge of the main face. This was mounted in front of a K-21 aerial camera and behind a rotating shutter turned by a 75-r.p.m. synchronous motor. The spectrograph is shown in Fig. 4, with the camera clamped to the lid of its wooden carrying case. By alternately exposing and covering the lens for 1/10 second, the shutter allows each frame of film to be exposed twice as long without being fogged by the sky background.

The shutter's most important function is to chop the trail of each meteor into segments, making measurements of its angular velocity possible. If a meteor recorded with this instrument is simultaneously photographed from another location 20 to 30 miles distant, the linear velocity, height, and orbit in space of the meteoric body may be determined.

The final sections of the segmented spectrum of a Perseid photographed through the rotating shutter are reproduced in Fig. 5. Conspicuous bursts are visible, especially in the H and K emission. Since the whole segment represents 1/10 second of exposure time, the bursts occurred about every 1/40 second, much too often to be separately detected visually.

Though this meteor was not photographed at a second station, we can estimate at what heights the bursts occurred if the meteor's velocity is assumed to have been 60 kilometers per second, the average for the Perseids. One difficulty is that the object was not seen visually, and therefore we do not know when during the 44 minutes of exposure it appeared.

Fortunately, the meteor was so close to the radiant that the direction on the stationary film from the meteor to the radiant (which moved with the stars) changed rapidly with time. The line extending the direction of motion of the meteor backward passed through the position of the radiant at the start of the exposure. Hence that starting time was used in the calculation.

The height of the final burst was found to be 91 kilometers, close to the 94 kilometers A. C. B. Lovell gives for the average height of disappearance of the Perseids. Evidently the bursts are not caused by an unusually deep penetration into the earth's atmosphere. In fact, the brightest Perseids reportedly come down to only about 80 kilometers, so here is a possible indication that the bursts result from a breakup that retards penetration. Although our calculations did not allow for the effect of air resistance on the meteor's velocity, it is unlikely that taking this into account would lower the estimated height by more than a couple of kilometers.

By the end of the 1956 Perseid season, in 28 nights of observation during nine showers, I had secured a dozen spectrograms. These showed that meteors of this swarm do not all have similar spectra, despite their common velocities. As with stellar spectra, the differences appear to be primarily excitational rather than com-

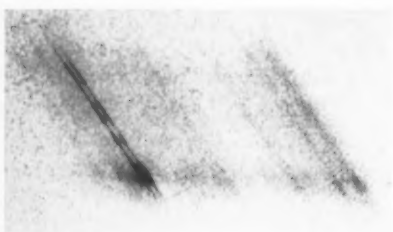


Fig. 5 (left). The H and K lines dominate this Perseid spectrum. At the extreme right is a fuzzy feature that is believed due to molecular nitrogen.

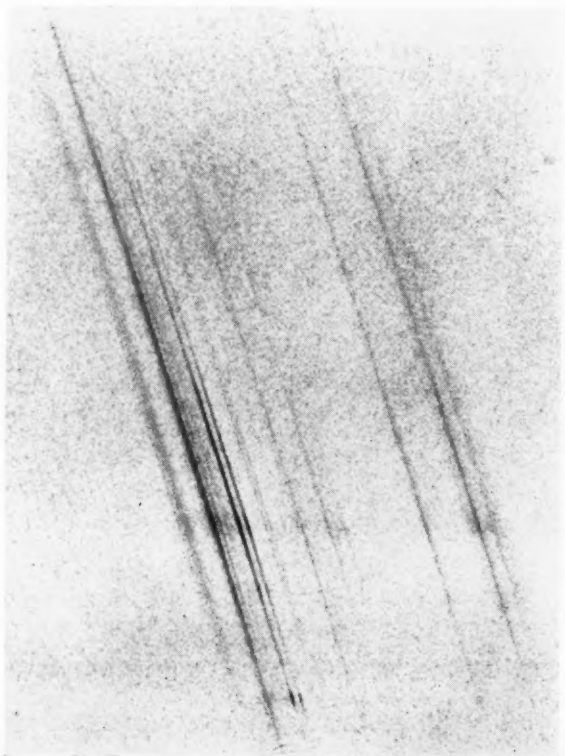


Fig. 6 (right). A meteor spectrum of type X, showing relatively low excitation. The first line to appear and last to vanish is the magnesium-iron blend to the left of the H and K calcium lines.

positional, and they seem related to the brightness of the meteor.

For example, the meteor in Fig. 3 was a spectacular object of magnitude −3 or brighter. In spectra of meteors this luminous, the H and K lines are likely to increase in brightness until, even before a burst occurs, they rival the strongest emission lines. And when a burst takes place, the H and K lines are strongly enhanced, while the ionized lines of other elements show the same effect to a lesser degree. The ionized magnesium line at 4481 angstroms is a good example.

One might expect, from an examination of Fig. 3, that the spectrum of a faint meteor could be completely below recordable brightness in the absence of bursts, yet be detected by its H and K lines if a burst occurs. A grating spectrum of this nature was obtained in 1955, with the H and K lines appearing in the first, second, and third orders, no other lines being visible. I believe that cases of this kind account for reports of meteor spectra showing no iron lines.

A meteor of intermediate brightness, if it has no pronounced bursts, may fade after attaining spectral class *X* (Fig. 6). Characteristic of the lower excitation in this spectrum is the weakness of the lines of ionized magnesium. The ionized calcium lines grow sharply at the small final burst, but the blended line of iron and magnesium at 3835 angstroms is the last to fade as well as the first to appear.

Faint Perseid meteors without bursts may not show the H and K lines at all. Such a spectrum, in which the strongest feature is the D line of sodium, is depicted in Fig. 7. Notice that the violet end of this spectrum is very weak.

Certain questions raised by these pictures can be answered only by studying spectra of higher dispersion. In some cases, there are blends of lines that cannot be separated in the low-dispersion prismatic spectra. In Fig. 5, for example, there is a line at the extreme red end that is the second strongest feature of the final segment as well as the strongest in the previous one. Although lines other than H and K are not sharp, this red line appears particularly fuzzy. Identification of this feature is difficult because the dispersion is only about 1,700 angstroms per millimeter in this region. It was tentatively considered to be a blend of neutral calcium lines.

Fig. 7. Faint Perseids may not show the H and K lines at all. The first feature to appear, at the top, is the green auroral line of oxygen; note its waviness. The sodium D line at the right is strong later.

Last summer at Palomar Observatory, I obtained a Perseid spectrum with the 18-inch Schmidt telescope showing more clearly a similar structure in the red. It is obviously not a single line or even a pair of lines. The provisional wave length range corresponds to that of the first positive group of bands in the spectrum of the nitrogen molecule, originally reported in meteoric spectra by A. F. Cook and Millman in 1955.

This emission was the first feature to appear in the Schmidt spectrum. Upon reexamining the original negative of Fig. 5, I found that the same feature could be readily seen in the third trail segment (counting backward from the terminal segment) and made out with difficulty in the fourth. Its similarity in both position and appearance to the one in the Schmidt spectrum would seem to indicate that it also originated from molecular nitrogen.

The spectrum in Fig. 7 exhibits a strong emission high on the trail that looks like a wavy spectral line, which I found to be, near the point of disappearance, at about 5570 angstroms. Ian Halliday, Dominion Observatory, wrote me that identical markings had been found on some high-dispersion spectra, permitting accurate determination of wave lengths. He has identified this as the auroral 5577 green line due to oxygen in the earth's atmosphere. An oxygen atom must be left undisturbed in the proper condition for about one second before it will emit this radiation. Thus, the slight curvature of the line in the figure may be attributed to the effects of winds at high altitudes that might produce noticeable distortion in a second. The line does not appear at lower levels, for the density of the air is greater and the excited oxygen atoms are jostled by their neighbors before the radiation can be emitted.

In 1954 I obtained, for higher-dispersion work, a Bausch and Lomb replica grating of 600 lines per inch, giving a dispersion of 160 angstroms per millimeter in the first order and 80 in the second. The first success with this equipment came in 1956, when a Perseid and a sporadic spectrum were obtained on the same roll of film. As Fig. 8 shows, some Perseid lines are well resolved that are blended in other spectra with this article. A detailed study of these two spectra has been submitted for publication elsewhere.

This summer I expect to be back at my observing post near Blairsden. Since meteorites are not recovered from the Perseids or any other meteor shower, spectra must be our principal source of information on the composition of these cometary fragments and their manner of radiation in the earth's atmosphere.

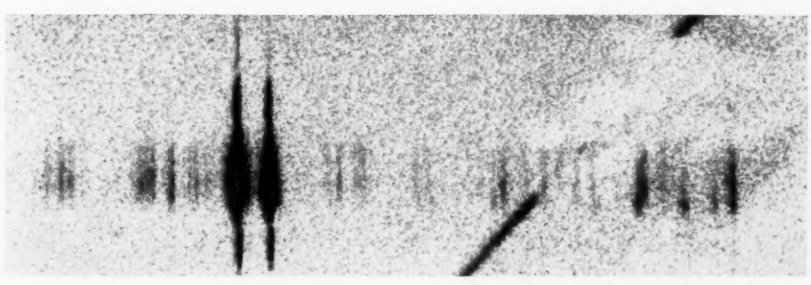


Fig. 8. Higher-dispersion spectra like this are obtained with a new grating spectrograph acquired in 1954. The two strongest lines are H and K of ionized calcium, while the fairly pronounced feature three inches from the left edge (not the slanted line caused by a star trail) is due to neutral calcium. The strong line at the right (long-wave-length end) is of ionized magnesium.

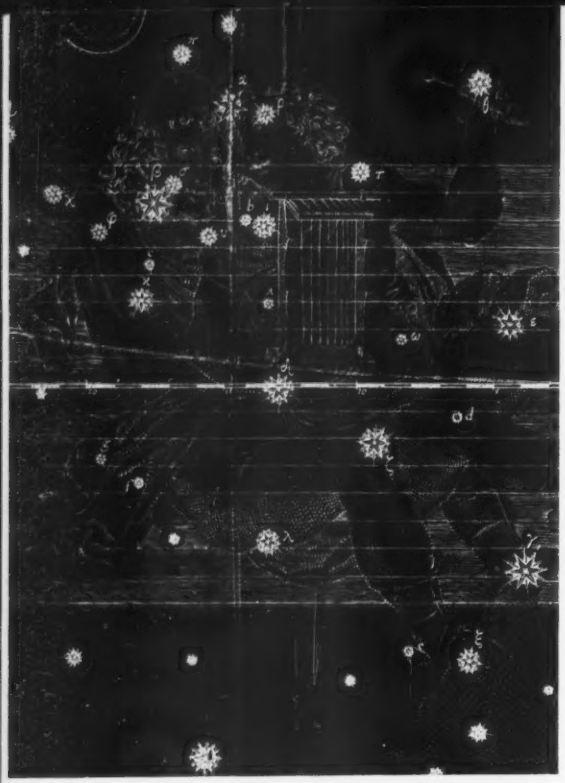
INDIRECT DETECTION OF SOLAR FLARES

(Continued from page 548)

the extreme right is the amplifier for the chart recorder.

Robert has his hand on the control of a frequency generator which is coupled to the atmospherics receivers. It can tune them over a range of 24 to 35 kilocycles per second, but they are generally tuned to approximately 27, because this region of the radio spectrum is free from man-made signals in the eastern part of the country.

In this same picture, my right hand is resting on the two main files where we keep our solar flare records, over 1,400 sun photo negatives, auroral and weather reports, tapes of auroral flutter on WWV at five megacycles per second, and Phototrack satellite observations. Elsewhere in the laboratory we have a barometer (part of our U. S. Weather Bureau climatological station), a tape recorder for WWV records during magnetic storms, a Phototrack camera, the 2.4-inch refractor, a short-wave radio, and a darkroom section.



Gemini, as pictured in Johann Bayer's star atlas of 1603. Castor, or Alpha Geminorum, is the bright star on the forehead of the right-hand twin. Pollux is in his brother's neck.

YY GEMINORUM

OTTO STRUVE, *National Radio Astronomy Observatory*

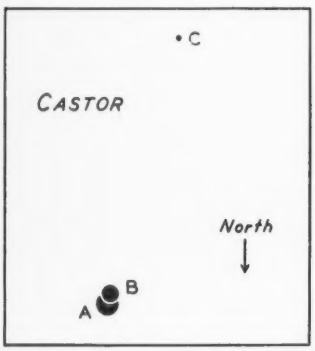


Fig. 1. In amateur telescopes, Castor is triple.

CASTOR is one of the most famous of all multiple stars. Even in small telescopes, it is easily seen as triple. As far back as 1719, the English astronomers Bradley and Pound observed it as two 2nd-magnitude stars, Castor A and B. These form a visual binary system, whose period of orbital revolution is 380 years, according to K. A. Strand. About 73 seconds of arc from this brilliant pair is a 10th-magnitude red star, which shares its proper motion. This is Castor C, a physical member of the group (Fig. 1).

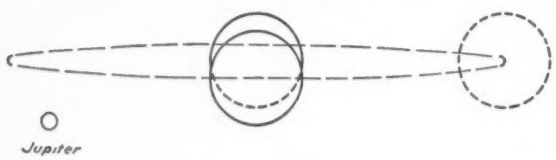


Fig. 2. A scale comparison of the YY Geminorum system with the planet Jupiter. Diagram from the "Astrophysical Journal."

In reality, there are six components of Castor. By 1904, it was realized that both bright stars are spectroscopic binaries. Some 20 years later A. H. Joy and R. F. Sanford found Castor C to be a double-lined spectroscopic binary, and it soon proved to be an eclipsing variable as well. Thus, this star is often referred to by its variable star designation — YY Geminorum.

It is in many respects the most interesting of the three pairs. Seven years ago, in the issue for October, 1952, I discussed some of its properties. Since then, many new problems have arisen in connection with this remarkable double star.

YY Geminorum consists of two nearly identical red dwarf stars of spectral type *M*. Each has about 0.64 times the sun's mass and 0.62 its radius. They revolve around their common center of gravity in 0.814 day, or approximately 20 hours. The relative dimensions of the system, determined by G. E. Kron of Lick Observatory, are shown in Fig. 2.

The light curve derived by Kron from photoelectric observations in 1948 is reproduced in Fig. 3. Notice that the curve is not smooth between eclipses, as it should be if the stellar disks were either uniformly bright or darkened symmetrically toward their limbs. Kron calls these irregularities "distortions," and explains them by assuming that one or both stars sometimes develop large bright and dark spots. These patches are carried around each star by its axial rotation, persisting in their locations with respect to stellar longitude and latitude for many orbital revolutions.

In 1951, Kron presented an interpretation of the light curve (Fig. 4): "The system is thought to be normal at phase $-0^d.12$, but a dark patch is beginning to come around the approaching limb of the eclipsed star *A*, as shown in drawing *I* (orbital and stellar rotation periods are assumed to be equal). From phase $-0^d.12$ to $-0^d.037$ the light decreases slowly, a phenomenon that is explained by reduction of the foreshortening of the patch as it approaches the stellar meridian. At phase $-0^d.037$, drawing *II*, the dark patch is covered by the eclipsing star *B*, with an apparent increase in brightness that is actually a reduction in the rate of light-decrease during the growth of the stellar-disk eclipse. Meanwhile, a bright patch follows the dark one around the limb by about 15° in astrocentric longitude, and at phase $+0^d.006$, shortly after conjunction, the bright patch (previously not noted either because it was greatly foreshortened or because it was eclipsed) is uncovered, as shown in drawing *III*, with a gain in brightness at this phase. The light of the bright patch more than compensates for the loss due to the uncovering of the dark patch immediately thereafter.

"Drawing *IV*, phase $0^d.15$, shows the star at its brightest, with the bright patch fully displayed and the dark patch foreshortened. By phase $0^d.32$, drawing *V*, the bright patch is so foreshortened that it has negligible effect, the dark patch has disappeared around the limb, and a normal secondary minimum is about to occur. This interpretation is admittedly not unique, for it must be kept in mind that the observed light-curve is a composite of light-variations that took place over a period of three months. Although small changes in the patch configurations during this time did not affect the variations between minima, nevertheless they could seriously affect the shape of the distortions during the eclipse process, where detail of patch configuration will be of importance. The noncontinuity of the data, therefore, makes difficult a unique and certain interpretation of the distortions in the present light-curve."

Recent spectroscopic observations indicate that, in addition to the long-enduring regions of activity discovered by Kron, there are small, irregular outbursts, mainly of hydrogen, lasting only about an hour.

Several spectrograms obtained at Mount

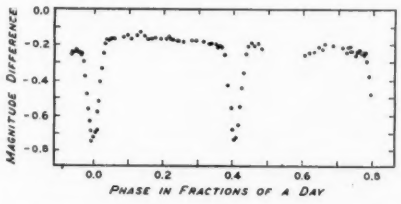


Fig. 3. Photoelectric measurements of YY Geminorum in visual light gave G. E. Kron this light curve of the system. Note the irregularities attributed to spottedness of the two stars.

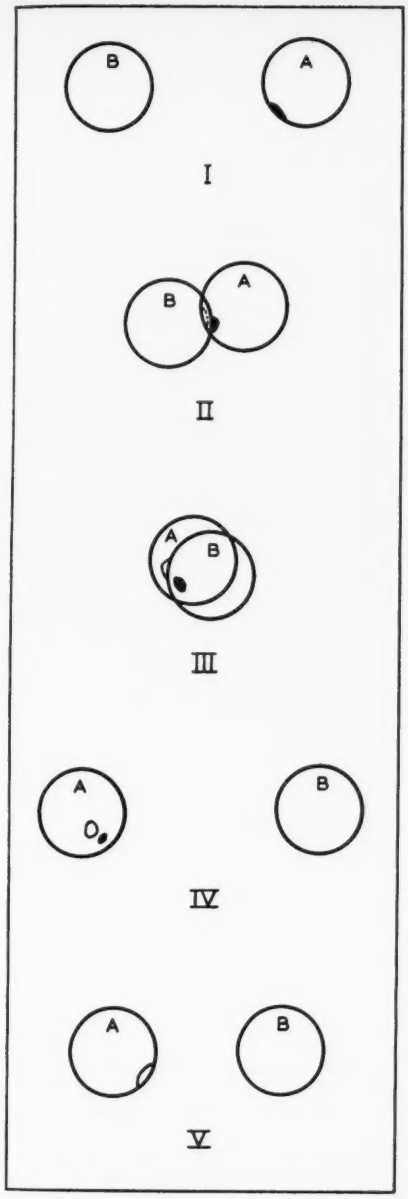


Fig. 4. Five stages in the eclipse of component A by component B are drawn by G. E. Kron to show how irregularities in the light curve may be caused by spots. See the text for a detailed explanation.

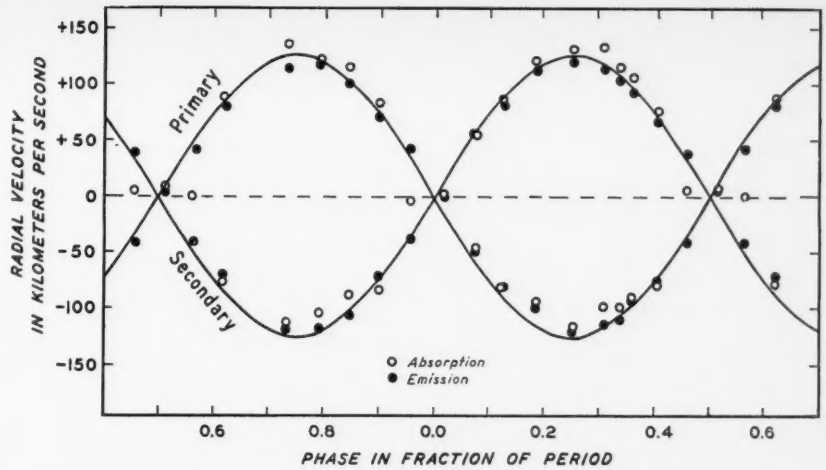


Fig. 6. The radial velocity curves of the two components of Castor C, from the author's observations. The persistent displacement between the bright and dark spectral lines is noteworthy.

Wilson Observatory in April, 1959, are shown enlarged in Fig. 5. The typical dwarf-*M* absorption lines are single at phases 0.0 and 0.5 (counted in fractions of a period since mid-eclipse), but double when the stars are at elongation, at phases 0.25 and 0.75. Emission lines, primarily those of singly ionized calcium (Ca II) and neutral hydrogen, behave in an identical manner.

As a rule, the two components of each calcium line have very nearly the same intensity at all phases when they appear. This has, however, not always been the case. For example, some spectrograms taken by G. H. Herbig in 1950 showed the violet components of both the H line of Ca II and the Balmer line Hδ to be much stronger than the red components, while the reverse was true about 10 hours later. Kron suggested the spots he detected might be related to such changes in the emission lines.

The new Mount Wilson spectrograms show only small differences in intensity of the double hydrogen emission lines. At phase 0.338 the red components of Hδ and Hγ were slightly stronger than the violet ones, while just over an hour later, at phase 0.405, the intensities were equal, indicative of the short duration of the hydrogen outburst.

Velocity curves of the two stars, determined from the new Mount Wilson observations, are presented in Fig. 6. Here, filled circles represent measurements of emission lines, open circles those of absorption lines. Both curves are considerably more accurate than any derived previously, and they show a most surprising result: With few exceptions, the black dots lie below the corresponding open circles. It looks as if the gas that produces the emission lines moves continuously toward the observer with an average velocity of seven kilometers per second. If this result should be confirmed by future observations, it would suggest that the emission lines are produced in large fields of prominences ascending from the surfaces of both stars.

Another result, not so easily explained, is the unsymmetrical distribution of the black dots with respect to the curves, which represent the earlier McDonald Observatory measurements that were discussed on page 302 of the October, 1952, issue. The 1959 observations, derived from very accurate measures of the emission lines, suggest fairly marked departures from circular orbital motion. The same conclusion can be drawn from the distribution of the open circles, but these represent less precise measures.

Since the velocity curves determined from both bright and dark lines agree in amplitude, we can infer that each star is surrounded by an emitting layer sharing the orbital motion. There is no indication that this layer is deeper on the facing stellar hemispheres. This is an interesting result, because W. A. Hiltner and I had previously found several close binary systems in which the emitting gases were localized in the tidal bulges of one or

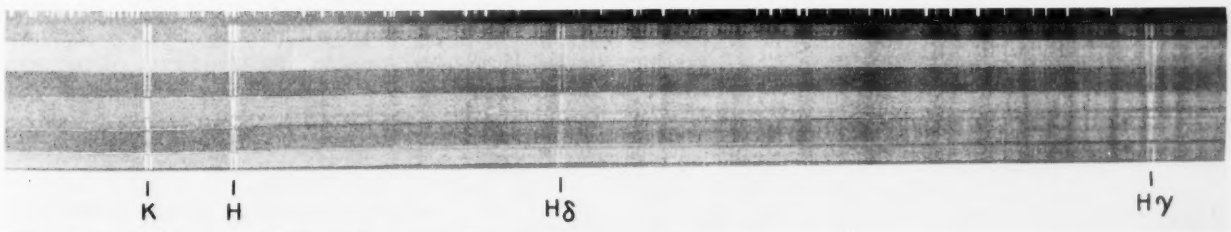


Fig. 5. Compare the emission lines in these spectra taken by the author with the Mount Wilson 100-inch telescope. From top to bottom, the phases are 0.128, 0.338, 0.405, 0.459, 0.513, 0.562, and 0.616 day, respectively.

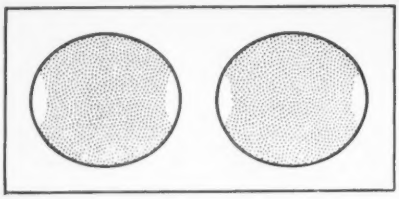


Fig. 7. Bright patches on the tidal bulges of a close binary, sketched here, show quadruple emission lines (Fig. 8) when the orientation of the system is broadside to the earth.

both components, as shown schematically in Fig. 7.

If there were such an uneven distribution of emitting gas in YY Geminorum, we would expect the emission lines from both stars to be split into two parts when the stars are at elongation. What we actually observe, however, is one single, broad emission line from each star (Fig. 8). In this case, all or most of both stellar disks contribute to the formation of the emission lines.

The widths of the emission components indicate 40 kilometers per second for the equatorial velocity of rotation of each star. This is almost precisely the value expected if the system revolves and rotates as a rigid body (Fig. 9), as the following calculation shows. The radius of either star is 4.3×10^5 kilometers, and its equatorial circumference 2.7×10^6 kilometers. If we divide the latter figure by the period of rotation I mentioned earlier, 0.814 day or, roughly, 7×10^4 seconds, the speed of rigid-body rotation is 39 kilometers per second. Possibly the widths of the emission lines have been slightly overestimated. Even so, the agreement is surprisingly good.

Perhaps the most interesting problem of YY Geminorum is its association with the binaries Castor A and B, each having a brighter component of spectral type *A*. These are main-sequence stars about twice as massive as the sun. Both are near absolute magnitude zero, some 100 times more luminous than the sun, whose absolute magnitude is about +5.

The "life expectancy" of a star is proportional to its mass divided by its luminosity, and indicates how long the star will remain at very nearly the same location on the main sequence in the Hertzsprung-Russell diagram. For example, the life expectancy of the sun is 40 billion years, and during this time only slight changes in the sun's temperature and luminosity are expected. Therefore, for the two *A*-type components of Castor, the life expectancies should be about 2/100 of the sun's, or only about one billion years.

Since A and B have already arrived on the main sequence, they may have completed their contracting phases of evolution several hundred million years ago. These introductory stages might have lasted about 5×10^7 years, considerably less than the duration of the contraction stage of the *M*-dwarfs of YY Geminorum, some 10^9 years. Have these stars had time to complete this evolutionary stage, or are they still contracting? If the latter, the two red dwarfs would be related to T Tauri stars — irregular variables of late spectral type associated with dark nebulae.

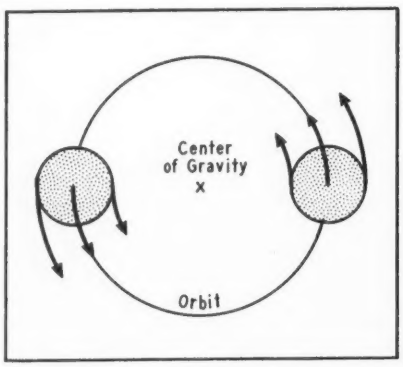


Fig. 9. Schematic representation of a binary system with rigid rotation.

Although we cannot prove this conjecture, since neither the duration of Helmholtz contraction for an *M*-type dwarf nor the life expectancy of an *A* star is accurately known, the idea, first suggested by S. S. Huang, is worth further exploration.

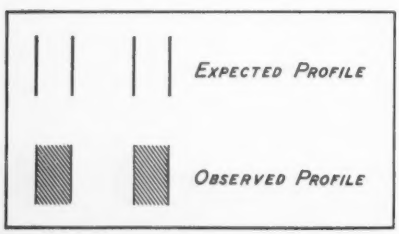


Fig. 8. Above is the quadruple pattern each emission line should show under the conditions of Fig. 7. However, YY Geminorum at quadrature shows double lines. Their breadth indicates that the emission comes from all parts of each star's disk, and also that the entire system rotates as a rigid body, as sketched in Fig. 9.

QUESTIONS... FROM THE S+T MAILBAG

Q. Does the Horsehead nebula in Orion have a Messier number?

A. This dark cloud was not listed by Messier. It is superimposed on the diffuse nebulosity IC 434, about half a degree south of the star Zeta Orionis. For a description and picture of the Horsehead, see the December, 1957, issue, page 84.

Q. Do any asteroids beside the Trojans have masculine names?

A. Minor planets 1036 Ganymede, 944 Hildalgo, and a few others are designated in this way to indicate exceptional orbits.

Q. What does ATM mean?

A. This is an abbreviation for Amateur Telescope Maker.

Q. When is the next transit of Mercury visible in the continental United States?

A. November 7, 1960. The beginning will be observable all over the country except for the Pacific Northwest; the ending will be seen everywhere in this country.

Q. How many light-years are there in a parsec? a kiloparsec? a megaparsec?

A. A parsec is 3.26 light-years. Since a kiloparsec is 1,000 parsecs, it is 3,260 light-years; a megaparsec is a million parsecs and hence 3,260,000 light-years.

Q. What magnification is needed to show readily the rings of Saturn?

A. Saturn's rings can be seen with as little as 30 power, but 150 to 300 power gives a much more satisfactory view.

Q. What is meant by a forbidden line in a spectrum?

A. It is a line that is not observed under ordinary laboratory conditions. Such lines are caused by transitions that require the radiating atom to remain undisturbed for relatively long periods of time (for instance, a second). This is possible only under conditions of exceedingly low pressure, as in the upper reaches of the earth's atmosphere or in gaseous nebulae, where atomic collisions are fairly infrequent. W. E. S.

FIRST REPORTS OF VENUS-REGULUS OCCULTATION

As this issue goes to press, messages come to hand concerning observations of the occultation of Regulus by Venus on July 7th, from the expeditions sent by Harvard Observatory to seven observatories abroad (see July issue of this magazine, page 483).

Harvard director Donald H. Menzel made excellent visual observations at Catania, Italy, the disappearance of Regulus being unexpectedly sudden, requiring only about three seconds. Sky brightness and poor seeing hindered the photographic program.

At Madrid Observatory, H. C. Ingrao visually timed the disappearance at 14:19:37 Universal time, and reappearance at 14:30:43. J. Allen Hynek described the event as a beautiful spectacle, but his photoelectric photometry was hampered by boiling images at the time of emersion.

At Péridier Observatory in southern France, G. de Vaucouleurs obtained good visual and photoelectric results, noting the fading time as five seconds. Owen Gingerich, who went to Beirut, Lebanon, was able to secure a partial motion-picture record despite cumulus clouds. At Merate, Italy, valuable motion pictures were secured, but haze made photoelectric work impossible. It was cloudy at Asiago, Italy, and at the Vatican Observatory rain was falling.

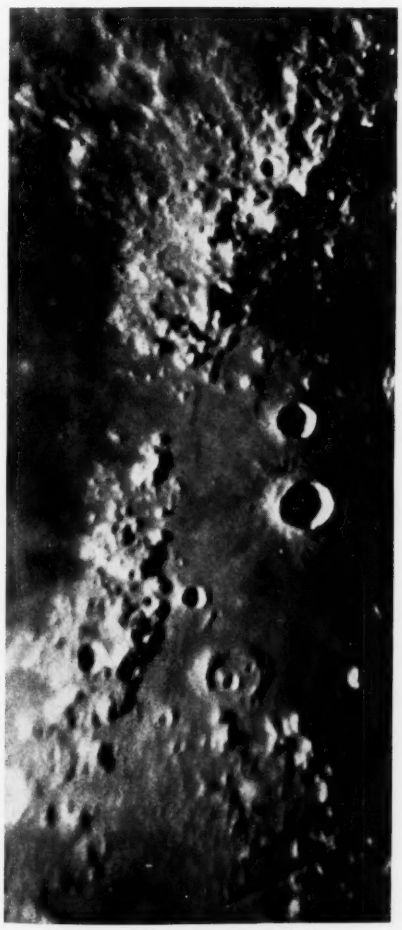
NEWS NOTES

PROFILE OF A LUNAR RIDGE

Gilbert Fielder, an astronomer at the University of Manchester, England, has been measuring photographically the heights of lunar features. He is using the 24-inch f/30 refractor of the Pic du Midi Observatory in France for lapse-rate motion pictures, with a technique similar to that tried experimentally at the McMath-Hulbert Observatory more than 20 years ago.

By means of automatic equipment, a ¾-second exposure is made once a minute to show the changing position of the long shadow cast by an elevation at the time the sun is rising or setting on a particular part of the moon. Measurements of the successive shadow lengths give the differences in vertical elevation of the country across which the shadow tip travels.

The first results of this project have been published in the *Monthly Notices* of the Royal Astronomical Society, Vol. 118, No. 6. They concern a wrinkle ridge in the westernmost part of Mare Imbrium, about 20 miles east of the mountain peak Caucasus β. This ridge, extending roughly north-south, is a lesser counterpart of the well-known Serpentine Ridge in Mare Serenitatis.



The ridge Gilbert Fielder measured is 1⅛ inches from the left edge and 2¾ inches from the bottom. It is inconspicuous in this photograph by Latimer J. Wilson, taken when the sun was too high for the ridge to be well shadowed.

The profile of the ridge was obtained by tracing the retreat of the mountain peak's sunrise shadow. The ridge is broad and relatively low, with minor ridges along its top, while its western face has some sharp drops. According to Dr. Fielder, the highest point on the wrinkle ridge is 490 ± 90 feet above the lowest point of the neighboring plain, while the ridge's base is 12 miles wide.

From these characteristics, and especially from the fact that there is no significant difference in the level of the plain on either side of the crest, the English astronomer concludes that the ridge is not a frozen wave of lava. This contradicts the interpretation of wrinkle ridges suggested by Ralph Baldwin in 1949.

COMPLETION OF THE AGK₂

With the publication of the last four installments of a 15-volume catalogue containing accurate positions of 185,187 stars, an enormous co-operative enterprise by seven European observatories has been successfully concluded. The work is known as the AGK₂, from its full title, *Zweiter Katalog der Astronomischen Gesellschaft.*

The German Astronomical Society (Astronomische Gesellschaft) had earlier sponsored a catalogue of the positions of all stars as bright as visual magnitude 9.0 between the north celestial pole and declination −2°. Twelve observatories shared in the observation of these stars with meridian circles, between the years 1868 and 1908. In 1921 it was decided to repeat this enterprise photographically, taking utmost pains to achieve high modern standards of accuracy.

For homogeneity in the new program, all the observations were made within a four-year interval, 1928 to 1932. The positions of 12,000 reference stars were measured with meridian circles at Bergedorf, Bonn, Poulkovo, Breslau, Heidelberg, and Leipzig. The first three of these observatories took the photographs from which the catalogue positions were to be measured.

They used identical cameras, each having a 6.3-inch objective of 81-inch focal length, with a four-element Zeiss design chosen to minimize optical distortion over the 5-by-5-degree field. The plate centers were spaced so that each star appeared on at least two photographs. Each plate had two exposures, of 10 and three minutes, made when the field was within an hour of the meridian, in accordance with good astrometric practice.

In the division of the work, declinations +90° to +20° were photographed at Bergedorf Observatory, near Hamburg, and +20° to −2° at Bonn Observatory. The zone within 20 degrees of the celestial pole was also observed at Poulkovo Observatory, but the Soviet results were separately published in 1937. In addition, about 1,700 stars that could not be measured on photographs for reasons such as duplicity were observed visually with the meridian circle at Babelsberg Observatory, near Berlin.

The gigantic task of measuring the photographs and carrying out the calculations was superintended by R. Schorr and A. Kohlschütter, the directors at Bergedorf and Bonn, respectively. After Schorr's death, his role was filled by his successor, O. Heckmann. Due to long delays occasioned by World War II, the first volume of the 15 was published in 1951, for the Bergedorf zone +70° to +90°. Subsequently, the other volumes have been produced, the set now being complete.

While the AGK₂ was in preparation, Yale University Observatory was also deriving photographic zone catalogues of stars, some in the same parts of the sky as the European program. The Yale stars were observed over several decades with different cameras, and their reference stars are not all in the same fundamental system.

Thus, the Yale catalogues are not as homogeneous as the AGK₂, but they contain proper motions of the stars, which the AGK₂ does not. However, the German astronomers are planning a repetition of the latter, to be known as the AGK₃, and comparison of the star positions in these two catalogues, based on observations about three decades apart, should yield very accurate proper motions.

IN THE CURRENT JOURNALS

THE BARRINGER METEORITE CRATER, by O. Richard Norton, *Griffith Observer,* May, 1959. "Only one indisputable conclusion has been reached and that is that the Crater is definitely of meteoritic origin. This conclusion has motivated contemporary scientists to search around the world for other possible meteorite craters."

AN ANCIENT GREEK COMPUTER, by Derek J. de Solla Price, *Scientific American,* June, 1959. "The Antikythera mechanism must therefore be an arithmetical counterpart of the much more familiar geometrical models of the solar system which were known to Plato and Archimedes and evolved into the orrery and the planetarium."

VARIABLE STARS IN STAR CLUSTERS, by Helen Sawyer Hogg, *Journal* of the Royal Astronomical Society of Canada, June, 1959. "Now, rather unexpectedly, the variables in galactic clusters (long thought to be practically absent) are beginning to assume real importance."

AMERICAN ASTRONOMERS REPORT

Here are highlights of some papers presented at the 102nd meeting of the American Astronomical Society at Rochester, New York, in March, 1959. Complete abstracts will appear in the Astronomical Journal.

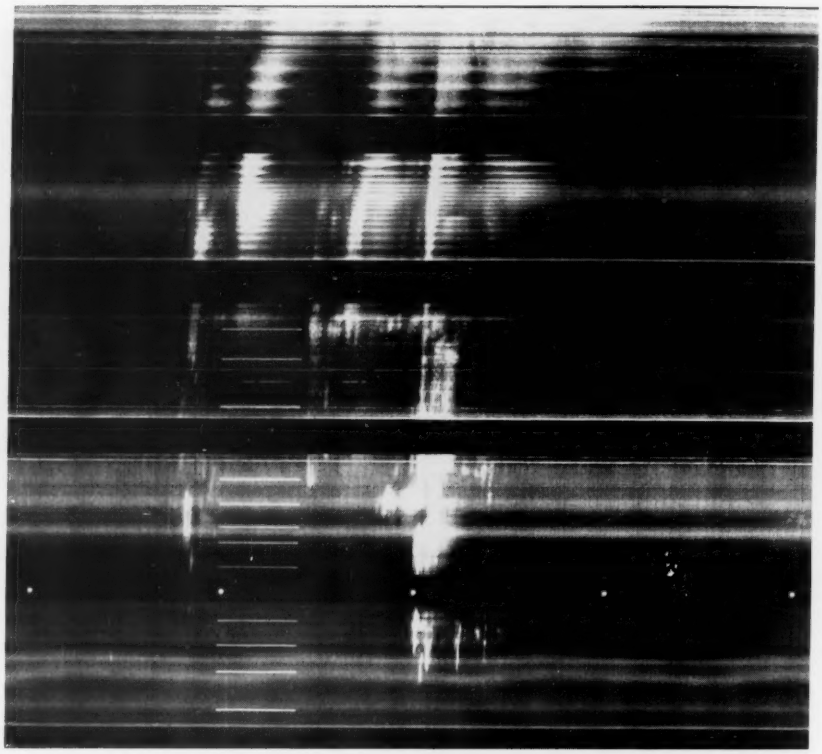
Solar Radio Bursts

The recording of intense short-lived bursts of radio energy from active areas on the sun at the Harvard Radio Astronomy Station, Ft. Davis, Texas, was described in this magazine for June, 1958, page 388. The original range of the equipment, 580 to 100 megacycles, has now been extended to much lower frequencies, 100 to 25 megacycles, providing records of radio noise from high in the solar corona. A. R. Thompson and A. Maxwell reported on the program.

The additional equipment makes use of a fixed antenna that does not track the sun, but that has a broad beam directed along the meridian at the celestial equator, so the sun can be monitored for the greater part of the day. Two narrow-band tunable receivers of high sensitivity, made by Airborne Instruments Laboratory, sweep repeatedly, one over the 25-to-50-megacycle octave, the other from 50 to 100 megacycles. Their outputs are displayed on cathode-ray tubes and photographed with a camera in which 70-mm. film is moving continuously.

Even at a station as remote from population centers as Ft. Davis, unwanted radio noise below 40 megacycles creates serious difficulties, being propagated in the ionosphere from all parts of the world. Special precautions have to be taken, so that in the uppermost section of the records the shapes and structures of high-corona phenomena are clearly visible.

Sample fast-drift bursts of February 20, 1959, are shown here. The duration of a burst is only about one second at 500 megacycles, low in the sun's atmosphere, but it is of the order of 20 seconds at 25 megacycles. The leading edge of a fast burst is well defined, resulting from a disturbance moving unchecked outward with a speed of 60,000 miles a second.



These fast-drift bursts of solar radio noise were recorded during a four-minute interval on February 20, 1959. Time increases from left to right, and the top of the record corresponds to a frequency of 25 megacycles per second, the bottom to 580. The bursts are due to disturbances in the sun's atmosphere traveling generally outward at enormous velocities. According to one theory, fast-drift bursts are cosmic rays moving at 0.3 the velocity of light; alternatively, they may be fast-moving shock waves. (See the picture on pages 544-5 for another example.) Harvard Observatory photographs on this page.

The new channels also record a much greater number of bursts with reverse drifts (increase of frequency with time), indicating that the disturbances are moving downward from high in the sun's atmosphere.

The present Harvard equipment monitors solar noise over a $4\frac{1}{2}$-octave range, more than at any other radio station of this type. This will be further extended by the addition of a receiver covering the 2,000-4,000-megacycle band.

At Ft. Davis, Texas, A. R. Thompson adjusts the antenna for the new channels of the solar sweep-frequency equipment, providing the uppermost two sections of the record pictured above. The large dipole for 25-50 megacycles is cross-polarized with the small dipole for 50-100 megacycles, and they are both mounted above a reflecting screen of wires.

Comets and Cosmic Chemistry

Are comets bodies that were formed with other members of the solar system from the original solar nebula? Are they accumulations of matter that with further growth could have become asteroidal or planetary objects? If so, studies of comets may provide a deep insight into the origin of the solar system.

Much evidence supports the view of J. H. Oort that a large cloud of comets surrounds the sun, most of them at such vast distances that they are invisible to us. Their temperatures are very low, so they can retain their structures as icy conglomerates of frozen matter — the comet model proposed by F. L. Whipple.

Bertram Donn, of Wayne State University, pointed out that even when relatively near the sun a comet remains cold, at a temperature of only 150° absolute, due to the cooling effect of the release of volatile gases. This means that the comets in general have undergone no extensive *chemical* changes since their probable formation out of the solar nebula.

Experiments indicate that molecules, when condensing slowly at low temperatures, often develop intricate structures, fragile and fluffy, such as meteoric particles appear to have. Since the latter are essentially all of cometary origin, evidently they have formed in space and have been swept up and preserved in comets. According to low-temperature chemical studies, they should contain a significant proportion of reactive molecules, such as hydrogen peroxide and acetylene, but not of free radicals. The particles made in the laboratory should be similar to the tiny interstellar grains composed of condensed molecules.

The magnetograph at Mount Wilson used by Robert Howard for mapping solar magnetic fields. The sun's image, 17 inches across, is at the focus of the 150-foot solar tower telescope. Below it is the polarizing analyzer, and a shielded box containing the photocells. Below these is the pit of the 75-foot spectrograph, which gives an 11-angstrom-per-millimeter dispersion in the green region of the fifth-order spectrum. Not shown is the strip recorder for the photocells. The principle of observation is the Zeeman effect: the splitting and polarization of the spectral lines of light that originates in a magnetic field.

Observations of Solar Magnetic Fields

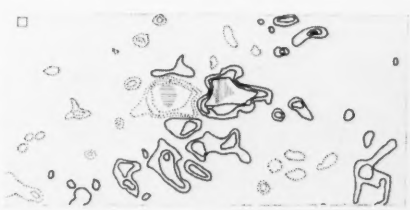
During the autumn of 1957 and the summer of 1958, the solar magnetograph in the 150-foot solar tower at Mount Wilson Observatory was used by Robert Howard for the detailed charting of the magnetic fields of both active and relatively quiet regions of the sun's surface.

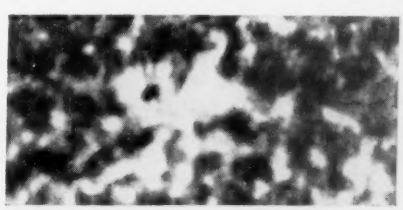
The tower telescope projects a 40-centimeter image of the sun. Dr. Howard made east-west scans across this image through a square aperture, nearly 2.5 millimeters or 10 seconds of arc on a side. As the light passed through the apparatus, a pen recorder traced a line on a moving paper strip, indicating the strength and polarity of the magnetic field's line-of-sight component. While the entire solar disk could not be scanned in one day, a morning was sufficient to cover an area large enough to show features of interest.

In this way, tracings were made around a total of seven sunspot groups. Five of these were observed on more than one day, and one was followed for eight days during the same solar rotation. From the resulting contour maps, it was found that field strengths of more than 75 gauss were common near the spots of a group, and on several occasions out to distances of several minutes of arc.

Day-to-day changes were frequent, the magnetic features forming and breaking up in an irregular fashion. On several occasions, near the middle of an area a small field of opposite polarity appeared, and by the next day it had grown enough to split the surrounding field, joining a region of like polarity. In most cases, the magnetic flux of a sunspot was balanced by the flux from the photosphere in its vicinity.

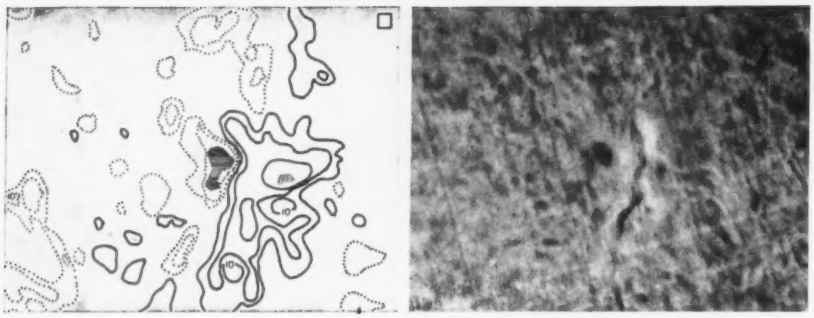
As rotation carries a sunspot across the sun's disk, the perspective changes, and





Above: A magnetic contour map of a sunspot region, made July 14, 1958, and compared with a calcium (violet) spectroheliogram. Contour lines represent fields of 10, 20, and 40 gauss; hatched areas are more than 75 gauss.

Left: A magnetic map of June 8, 1958, in which sunspot umbrae and penumbrae are drawn in solidly. Contour lines are for fields of 10, 25, and 40 gauss, hatched areas for greater than 50 gauss. The small square is the size of the scanning aperture, 10 seconds of arc on a side.



This map and spectroheliogram show the same spot group as the pair on the preceding page, from observations made three days earlier. Contour lines mark fields of 10, 25, and 45 gauss. The dark hydrogen filament is in a magnetically neutral area, between positive (dotted) and negative (solid) polarities.

therefore it was possible to find something about the true orientation of local magnetic fields, even though only their line-of-sight components were measured. The magnetic flux from the neighborhood of one sunspot group (Mount Wilson 13,363) decreased steadily as it passed from the east to the west limb of the sun. This was interpreted as an observational effect of the magnetic lines of force being inclined about 20 degrees to the vertical.

Dr. Howard compared his contour maps with calcium-light photographs of the same regions taken on the same days. As can be seen in the picture on page 557, the calcium emission regions match quite closely the 10-gauss contour lines. This agreement was generally best for areas near the sun's central meridian.

A similar comparison was made with solar photographs taken in the red light of the hydrogen-alpha line. Dark filaments (which are prominences viewed against the solar disk) seem to lie in magnetically neutral areas and, in all observed cases, between features of opposite polarity. Small hydrogen filaments tend to avoid the magnetic features that occur near sunspots.

These high-resolution magnetic observations support recent theoretical studies that indicate that magnetic fields may be associated with dark filaments. However, there are many puzzles. For example, not all magnetically neutral regions between features of opposite polarity are occupied by hydrogen filaments.

Spectrum of Jupiter

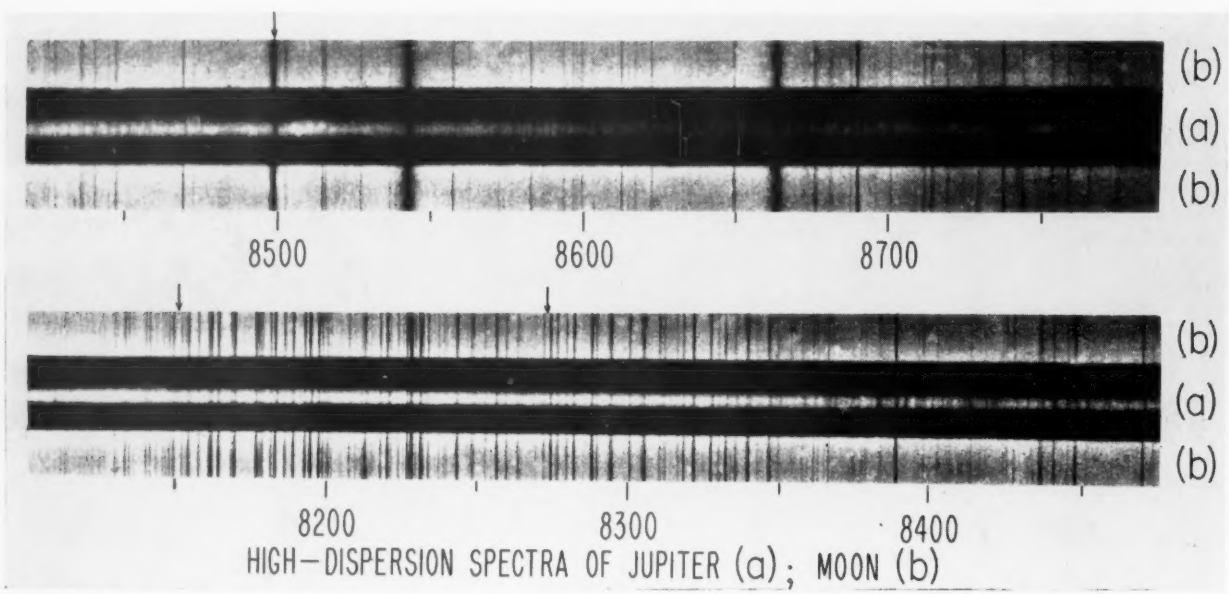
About 25 years ago, the most conspicuous absorption features in the spectrum of Jupiter were identified by R. Wildt as due to ammonia (NH_3) and methane (CH_4). Now, for the first time, observational demonstration has been given that molecular hydrogen (H_2) is a constituent of Jupiter's atmosphere.

This was done by C. C. Kiess, C. H. Corliss, and Harriet K. Kiess, National Bureau of Standards and National Geographic Society. They used the same concave-grating high-dispersion spectrograph on Mauna Loa, Hawaii, that was employed for their observations of Mars in 1956 (Sky and Telescope, April, 1957, page 266). Jupiter's spectrum was recorded between wave length 3600 angstrom units in the ultraviolet and 8700 angstroms in the infrared, with dispersions ranging from two to five angstroms per millimeter.

With such high resolution, very detailed spectra were obtained, in which the lines making up several molecular bands could be identified. For example, 50 and 135 lines were measured, respectively, in the 6450- and 7900-angstrom bands attributed to the ammonia molecule. Three lines in the band spectrum of molecular hydrogen have been identified, as marked in the accompanying photograph of the infrared region.

These relatively weak lines actually indicate a great abundance of hydrogen in Jupiter's atmosphere. Similar features (quadrupole lines) had previously been photographed in laboratory studies by G. Herzberg, and had been observed in the spectrum of Uranus.

At shorter wave lengths, the new spectrograms of Jupiter show a continuous absorption extending from 4200 angstroms to the 3600-angstrom limit of the survey. This appears to be the same as a feature observed visually by H. C. Vogel about 90 years ago. Dr. Kiess and his coworkers pointed out the close correspondence of this absorption with laboratory spectra of nitrogen tetroxide (N_2O_4). However, some specialists in the chemistry of planetary atmospheres regard the existence of this gas on Jupiter as unlikely.



First direct proof of the existence of free hydrogen in Jupiter's atmosphere is provided by these high-dispersion spectra, where arrows indicate weak dark-line features due to hydrogen molecules. Absorption lines occurring both in Jupiter's and the moon's spectra are of solar origin. The planet's lines are shifted redward and inclined – Doppler effects of relative recession and rotation, respectively. Photo courtesy C. C. Kiess, National Bureau of Standards.

ASTRONOMICAL SCRAPBOOK

Some Huygens Telescopes

IN 1959 two important centenaries call for celebration by telescope makers, amateur and professional. It is just 100 years since Léon Foucault announced his knife-edge test, known and used by every maker of telescope mirrors. Going back another 200 years takes us to 1659, when Christiaan Huygens published his book *Systema Saturnium*.

This told of the fulfillment of the secret dream of many an amateur astronomer: with powerful home-made instruments to settle decisively some famous astronomical problem, and to top it off with the discovery of a noteworthy new object in the sky. Both these feats were reported by the 26-year-old Dutch astronomer in his book.

Saturn had been a perplexing problem to astronomers ever since Galileo first viewed it in his optic tube in 1610. With the primitive telescopes of that time, the planet was variously seen as triple, single, oblong, or embellished with semicircular or elliptical arcs.

Huygens began to observe Saturn in 1655 with a nonachromatic refractor 12 feet long, made by himself. Later that year he pressed a 23-foot refractor into service, and in 1656 one 123 feet long. His systematic observations enabled him to prove conclusively that the curious phenomena of Saturn were due to "a thin, flat ring, nowhere attached, and inclined to the ecliptic." During this work, moreover, he discovered Saturn's brightest satellite, Titan, on March 25, 1655, with the aid of the 12-foot telescope.

This instrument was one of the very first Christiaan Huygens made after he took up lens grinding with his brother Constantyn, early in 1655. The former recorded that its objective was a single plano-convex lens, and that its ocular, giving a power of 50, was a simple lens of a little less than three inches focal length.

Fortunately, the objective of this telescope has been preserved. It was discovered in 1867 by P. Harting among the possessions of the physics department of Utrecht University. It is 2¼ inches in diameter, and is inscribed with the date February 3, 1655, and a Latin sentence, which is the same anagram Huygens had used to safeguard the priority of his discovery of Titan.* Harting carefully compared the inscription with Huygens' manuscripts preserved at Leiden Observatory, and found that they were in the same handwriting.

Huygens spoke in his book of a 12-foot telescope, whereas the focal length of this lens is 10.6 feet. The explanation seems to be that the old Dutch astronomer described his instruments by their over-all length, including dewcap and eyepiece. There seems to be no doubt that this is the actual objective used for the discovery of Titan.

Here was an interesting opportunity for modern tests of the performance of a famous 17th-century telescope. In 1883, J. A. C. Oudemans fitted this objective with a 3-inch eyepiece from another Huygens instrument, thereby obtaining a telescope practically identical with the original, as far as the optical parts were concerned. With its aid, the rings of Saturn were just recognizable, and the star Mizar was readily shown as double.

More extensive tests of the same object glass were made about 15 years later by the Utrecht astronomer, A. A. Nijland. He added a modern ocular providing a magnification of 88, and placed the assembled instrument on an equatorial mounting.

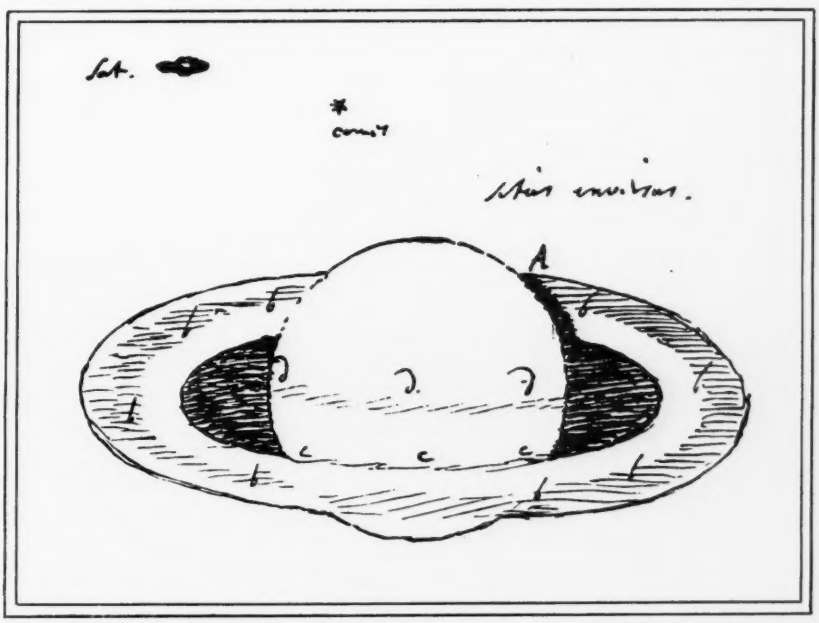
The results give us some insight into the difficulties under which the observer of 300 years ago worked. Even with the most careful adjustment, Nijland found that the telescope gave diffuse images. A 1st-magnitude star showed a bright, irregular central patch, from which extended colored rays marked by fragments of several diffraction rings. Only double stars with separations over five seconds of arc could be split. Jupiter and Saturn showed some surface features, but the moon alone, easiest of all telescopic test objects, offered to him a pleasing view.

The performance, according to Nijland, was not as good as that of another 17th-century objective he tested at the same time. This was made by Giuseppe Campani of Rome, and had a clear aperture of 1.65 inches and a focal length of 10.4 feet. It revealed Procyon as a perfectly round yellow disk, surrounded by neat diffraction rings.

Later in his career, Huygens made and used much larger and more effective instruments than the 12-foot. With single-lens objectives of small aperture, very great focal lengths minimize spherical aberration and render chromatic aberration less noticeable. This led to the use of telescopes of enormous length, whose wooden tubes, hung by ropes from poles, were very difficult to handle. This problem was eased by the Huygens brothers' invention of aerial telescopes — tubeless instruments, with the objective on a high tower and pointed with the aid of long cords held by the observer.

Three objectives for such telescopes, ground by Constantyn Huygens in 1686, are in the possession of the Royal Society of London. They have diameters of 7½, 8, and 8½ inches, and focal lengths of 122, 170, and 210 feet, respectively. The first of these is probably the same one mentioned in a revealing note in the *Philosophical Transactions* of the Royal Society for 1718:

"Much about the same time the excellent M. *Christian Huygens* of Zulichem, made the Society a present of the Glasses of a Telescope of 125 Foot length, with



Saturn, as observed by Christiaan Huygens on December 8, 1675, with a telescope 36 feet long, at Paris in company with G. D. Cassini. The upper part of the sketch shows the location of Titan with respect to Saturn. In the large Saturn drawing, A is the shadow of the planet on the ring, and ccc the shadow of the ring on the disk. The outer part of the ring was seen darker than the inner, the boundary being labeled bbb. On the planet, a dark belt is marked ddd. This pen-and-ink sketch in Huygens' observing book is reproduced from Volume 15 of his collected works.

*The anagram reads *Admovere oculis distantia sidera nostris, vvvvvvvccrrhnbqx*, which can be rearranged to yield *Saturno luna sua circunducitur diebus sexdecim horis quatuor*: Saturn has a moon revolving about it in 16 days four hours.

the *Apparatus* for using them without a Tube. . . . But those here that first tried to make use of this Glass, finding for want of Practice, some difficulties in the Management thereof, were the occasion of its being laid aside for some time. Afterwards it was designed for making perpendicular Observations of the fixt Stars passing by our Zenith, to try if the Parallax of the *Earths* annual Orb might not be made sensible in so great a Radius, according to what Dr. *Hook* had long since proposed: but in this we miscarried also, for want of a place of sufficient height and firmness, whereon to fix the Object Glass, so that it lay by neglected for many Years."

It is quite clear from this why short, convenient reflecting telescopes were so popular after they became generally available in the mid-18th century.

JOSEPH ASHBROOK

This article is based on the very complete account of Huygens' telescopes in pages 9 to 26 of Vol. 15 of *Oeuvres Complètes de Christiaan Huygens,* published in 1925 at The Hague under the auspices of the Netherlands Academy of Sciences.

CATALOGUE OF SOLAR FLARES

Three Czech astronomers have recently published a catalogue of 438 major eruptions of the solar chromosphere recorded from 1859 to the end of 1956. This 78-page compilation by L. Fritzova, M. Kopecky, and Z. Svestka forms *Publication* No. 35 of the Astronomical Institute of the Czechoslovak Academy of Sciences.

Only very bright flares rated greater than 2 on the 1-2-3 scale of importance are included, and about eight per cent are in the highest class, 3+. Detailed information given for each flare includes position on the sun's disk; its area, intensity, and duration; and facts about geophysical disturbances associated with the flare. These disturbances involve auroral displays, large variations in the earth's magnetic field, ionospheric changes, and increases in cosmic rays.

One indication of the widespread interest in solar observing is that the records of these 438 flares were gathered at 46 different observatories in all of the continents except Antarctica. This compilation will be of great usefulness to all investigators of solar-terrestrial relations.

The catalogue forms part of a 444-page paper-bound volume containing Nos. 34 to 42 of the astronomical institute's publications. The papers are mostly in English, but some in German or French, and cover many subjects. There is a long report on Czechoslovakian studies of Comets Arend-Roland and Mrkos; J. Ruprecht discusses the internal dynamics of galactic star clusters; and M. Kopecky analyzes the properties of sunspot groups of 1874 to 1950.

Copies of this new volume may be obtained from ARTIA, P. O. B. 790, Prague 2, Czechoslovakia.

OBSERVING THE SATELLITES

Space Astronomy

EXTENSIVE PLANS for telescopic observations from orbiting artificial satellites are now being drawn up by six observatory teams in co-operation with the National Aeronautics and Space Administration. The problems of stabilizing and accurately pointing a telescope by remote control have feasible solutions, as described in this department last October. We can now look forward to having key astronomical observations made with a wide variety of optical systems from the outer fringes of the earth's atmosphere or beyond.

American launchings of telescope-carrying satellites are unlikely before 1962. In present planning, the launching vehicle for the larger experiments will be the Vega two-stage booster now being developed for NASA by Convair-Astronautics. It is essentially an Atlas first stage topped by a modified Vanguard first stage. The Vega system is designed to send about 2,500 pounds into an orbit 500 miles above the earth's surface, where there is practically no atmosphere to interfere with celestial observations.

James E. Kupperian, Jr., is responsible for co-ordinating NASA's work in vehicle development, stabilization, telemetry, satellite power supply, and providing the necessary ground stations.

One of the most important types of observation will be stellar spectroscopy in the ultraviolet. James Milligan of NASA is developing a slit spectrograph that is to provide one-angstrom resolution. Probably the light collector will be a 30-inch mirror. Another spectrograph is being designed at Princeton University by Lyman Spitzer, Jr., for observing interstellar absorption lines. In this instrument, two phototubes scan the spectrum, comparing the intensities at different wave lengths.

Equipment is being planned by Arthur D. Code, of Washburn Observatory, for photoelectric absolute photometry of stars in ultraviolet and visual light. Probably an 8-inch telescope will be used, with filters to isolate the different spectral regions.

Another NASA-sponsored project in satellite astronomy involves the sun. Leo Goldberg, of the University of Michigan, is devising a series of three spectrographs to record the ultraviolet solar spectrum from 80 to 3000 angstroms. As he wishes to investigate identifiable, small portions of the sun's disk, the pointing accuracy of the telescope system is intended to be about six seconds of arc.

Further artificial satellite experiments of astronomical interest deal with radiations to which the earth's atmosphere is highly opaque. Malcolm Savedoff, University of Rochester, will examine hard X-rays emitted by extraterrestrial sources. In the radio astronomy experiment of Fred T. Haddock, University of Michigan, long wires will be trailed from the satellite or small loop antennas used to receive radiations of 0.25 to 20 megacycles.

Mapping the entire sky in three ultraviolet spectral regions is a satellite program under study at the Smithsonian Astrophysical Observatory by Fred L. Whipple and Robert J. Davis. Details of their proposal were given in the October, 1958, issue, page 625, and in June, 1959, page 437.

Most far-reaching of all such plans is to place a reflecting telescope of 50 inches aperture in a satellite. The National Science Foundation has granted $160,000 to Kitt Peak Observatory, near Tucson, Arizona, to support feasibility studies by Aden B. Meinel. The observations made with this instrument would be relayed back to earth by television or by radio communication channels.

Electrical Power Sources for Satellites

AS artificial satellites and space probes become more complex, the demand will increase for lightweight sources of electrical energy that are reliable under the exacting conditions of spaceflight. Considerable effort is now being devoted to improving existing power sources, and to developing new ones.

Every space vehicle launched to date has carried chemical batteries to power some or all of its electronic equipment. All these batteries have died, usually within two or three weeks, whereas the solar-energy converters (used so far only as supplementary sources, in Vanguard I and Sputnik III) are still operating after more than a year.

The familiar chemical cells with metallic reactants (such as the silver and mercury types) can be designed to resist acceleration and vibration, and are insensitive to the radiation and vacuum of space. Satellites can be suitably painted to hold their interior temperatures close to 70° Fahrenheit, where battery performance is usually best. Some varieties are well suited for delivering high, brief peaks of power.

These properties, together with great reliability, explain why chemical batteries have been so extensively used, despite their low efficiency. One measure of the efficiency of a battery is the ratio of energy output to weight, only about 80 watt-hours per pound for the best chemical types available. This is a serious limitation, for each payload pound placed in orbit now requires about half a ton of launching vehicle to get it there!

Under development is a variety of chemical battery called the fuel cell, in which electrical energy is derived directly from continuously supplied reactants such as hydrogen and oxygen. Already an ef-

ficiency of about 300 watt-hours per pound has been achieved, and 1,400 is theoretically possible. Fuel cells for space missions may become available within a year or two.

Another approach is the conversion of nuclear energy into electrical energy. A recently completed five-pound generator uses $\frac{1}{3}$ gram of radioactive polonium-210 to heat a semiconductor thermocouple junction. Such devices may attain an efficiency of about 3,000 watt-hours per pound when the half-life of the radioactive source is about 136 days. But there is the problem of removing unwanted heat from the cold junction by radiating the heat into space from the satellite's skin; also, shielding may be necessary to protect other components.

Other possibilities for the future are systems in which one thermocouple element is replaced by a plasma of ionized gas, or in which a fission reactor generates electricity directly from ionized gases.

In all the foregoing methods, the electrical energy comes from materials carried within the satellite. However, at the earth's distance from the sun, each square meter of the satellite's surface is bathed in 1,350 watts of solar radiant energy. This is now being tapped and converted to electrical energy by the photovoltaic cells of Vanguard I and Sputnik III.

Solar batteries of the silicon-junction type can utilize about 10 per cent of the incident energy. The weight of the crystals and their housings leads to an overall efficiency of about 3,000 watt-hours per pound — for the first year. However, the solar battery continues to deliver power, and the efficiency rises with every added hour of performance. After nearly a decade, however, the battery output would be reduced to half, largely by micrometeorite erosion of the fused-silica windows and by the effects on the semiconductors of solar X-rays.

CIVIL AIR PATROL BROADCAST SCHEDULE

Station	*Kilocycles*	*Time*
VP0, Washington, D. C.	4275	19:00 and 20:00 EST
VP01, Mitchell AFB, N. Y.	2374 or 4585	20:30 EST
VP02, Sumter, S. C.	4467.5	20:30 EST
VP03, Inkster, Mich.	4507.5	20:30 EST
VP04, Nashville, Tenn.	4467.5	20:30 CST
VP05, Minneapolis, Minn.	2374	20:30 CST
VP06, Dallas, Tex.	4507.5	20:30 CST
VP07, Lowry AFB, Colo.	4507.5 or 4585	20:30 MST
VP08, San Francisco, Calif.	4585	20:30 PST

Shorter Notes

TWO satellites now in orbit are expected to fall to earth during 1959: Explorer IV by mid-September, and Sputnik III toward the end of the year. The career of Explorer I will probably come to a close by late 1962. These are forecasts from the Smithsonian Astrophysical Observatory.

Scheduled for early launching is a 100-foot inflatable plastic balloon, with reflective coating. Timed photographs that show the disappearance of this satellite into the shadow of the earth, or its reappearance from eclipse, against an identifiable background of stars are wanted by the Research Station for atmospheric refraction studies.

Observers who do not have access to satellite predictions for their geographical locations can calculate them on the basis of the modified orbital elements reported each Tuesday and Friday evening by Civil Air Patrol radio broadcasts. These broadcasts currently follow the schedule given above.

Special broadcasts will be made nightly at these same times in the event of an artificial satellite with a rapidly changing orbit.

Full instructions for making local predictions from the data in these broadcasts are given in *IGY Satellite Report Series*, No. 7. This is obtainable at $1.00 a copy, postpaid, from the Printing and Publishing Office, National Academy of Sciences, 2101 Constitution Ave., N.W., Washington 25, D. C.

MARSHALL MELIN
Research Station for Satellite Observation
P. O. Box 4, Cambridge 38, Mass.

LETTERS

Sir:

In a letter published on page 307 of the April issue of Sky and Telescope, Gerard P. Kuiper discusses my spectroscopic observations of the lunar crater Alphonsus on November 2-3, 1958. He states that my identification of a bright band in the spectrum of the central peak as the Swan band at 4737 angstroms of molecular carbon (C_2) is incorrect. I cannot agree with this.

Dr. Kuiper refers to the absence of structure in the observed emission band. However, this structure, while inconspicuous in the photograph that accompanies my article (February issue, page 185), stands out quite clearly in the microphotometric measurements of the original. These show a very complex structure of the band, with well-pronounced maxima of intensity which agree within one angstrom with those of the Swan band. The most pronounced of the maxima are 4737 and 4715. At the same time, undoubtedly, other bands of unknown origin are superimposed on the Swan band.

The other objection of Kuiper's is of a fundamental character; he states that the Swan band must be observed in absorption, not in emission, on the sunlit surface of the moon. But we must take into account the extreme rarefaction of the effusing gases. At such very low densities, molecular collisions cannot play any role. Therefore, all processes of radiation transfer will be of the pure scattering type, without true absorption.

In this case, if the optical depth is large the reflection coefficient must be close to unity for the wave lengths in question. The background on which this radiation was projected has the reflection coefficient of the Alphonsus central peak, equal to only 0.013 when the sun's altitude is 18 degrees, as at the time of my observation. Actually the Swan band was only 40 per cent brighter than this background, and consequently the optical depth was about 0.005. From these considerations it follows that a very rarefied lunar or planetary atmosphere must give emission and not absorption bands. The bands in the spectra of Jupiter, Saturn, and other planets are formed by true absorption in their atmospheres, which arises from collisions between molecules under conditions of considerable density.

From this value of the optical depth of the gases above the Alphonsus central peak, we can estimate the amount of gas. Assuming the oscillator strength as 2×10^{-2} and the effective width of the band as 100 angstroms, we deduce that over each square centimeter of the lunar surface there were 10^{14} molecules of C_2. The spectrogram shows that the Swan radiation was observed over an area of about 100 square kilometers. Hence the total number of carbon molecules was 10^{26}.

The velocity of the C_2 molecules, formed as sunlight dissociated the primary molecules, must have been of the order of one kilometer per second. Hence, a halt in the outflow of gas would stop all radiation phenomena within about 10 seconds. For the maintenance of a constant density, an outflow of 10^{25} C_2 molecules per second was necessary — approximately one cubic meter of this gas at terrestrial atmospheric pressure. Since the gas flow continued for not less than half an hour, the total amount of carbon gas that emerged from the central peak of Alphonsus was approximately a few thousand cubic meters. As probably not more than one per cent of the primary molecules formed C_2, the total amount of gas released from the central peak was of the order of a few hundred thousand cubic meters.

The probable density of the gas was approximately one-billionth that of the earth's atmosphere at sea level. As said above, at such a density collisions cannot play any role and we can expect to observe only emission bands in the spectrum.

N. A. KOZYREV
Poulkovo Observatory
Poulkovo, U. S. S. R.

AAVSO MEETS IN CHICAGO

CHICAGO was the site of the American Association of Variable Star Observers' spring meeting, May 29-31. Over 50 members from the South, Middle West, and New England attended the sessions, which were held in the Adler Planetarium.

Hosts for the meeting were the Chicago Astronomical Society and Albert V. Shatzel, Adler director. The Friday evening lecture was given by Dr. George Van Biesbroeck, Yerkes Observatory, who spoke on Mira as a visual binary star. Afterwards, Dr. Shatzel led the group on a tour of the building and demonstrated the Zeiss projector.

The papers given at the Saturday session were varied. "Bode's Law Modernized" was the topic of George Diedrich. Clinton B. Ford gave methods for planning an observing program and check list. V Sagittae, which has overlapping cycles of 530 and 17 days, was described by Robert Adams, and Joseph Anderer gave a talk on astronomical stamps, showing color slides.

A posthumous paper by Dr. Chang Yuin of Hong Kong was read. It dealt with distortions in the light curves of very-short-period variables when determined photographically. Takaski Murayama, Nagoya, Japan, contributed a study of correlations between cosmic rays and the variations of the star W Orionis. AAVSO director Margaret W. Mayall described a new variable in Camelopardalis that was discovered by Robert Greenley.

After the banquet Saturday night, the group went to the Dearborn Observatory in Evanston. Though cloudy skies prevented observing, the observatory's electronic computer was inspected.

R. NEWTON MAYALL
American Association
of Variable Star Observers

N. HOLLYWOOD, CALIFORNIA

An ambitious project of the San Fernando Valley Astronomical Society was mapping the planet Mars during its 1958 opposition. In this co-operative observing program, telescopes of 2.4 to 10 inches aperture were used. Numerous drawings and photographs were made, from which a composite map of the planet was constructed. The president of the society is J. W. Harvey, 11640 Weddington St., N. Hollywood, Calif.

JUNIORS IN OREGON, MISSOURI, AND KENTUCKY

There are 12 members in the Seaside Amateur Astronomers, including the senior advisor, Robert N. Sealy, 2456 Ocean Vista Dr., Seaside, Ore.

Nine juniors have formed Our Lady of the Ozarks Astronomy Club. The president is John Smietanka, Our Lady of the Ozarks, Carthage, Mo.

The Glasgow Junior Astronomical Association has eight members under the leadership of Charles W. Luster, 101 E. Cherry St., Glasgow, Ky.

Amateur Astronomers

PROGRAM OF THE DENVER CONVENTION

KEN STEINMETZ, general chairman of the Nationwide Amateur Astronomers Convention to be held at Denver, Colorado, at the end of this month, has released the following program. Five societies in the Mountain States region are arranging the meeting: Denver, Boulder, Colorado Springs, and Pueblo, Colorado, and Cheyenne, Wyoming.

Thursday, August 27

All day to 5:00 p.m.	Setting up of exhibits, Student Union building.
1:00 to 5:00 p.m.	Registration.
7:00 to 10:00 p.m.	Informal get-together, Student Residence Halls.

Friday, August 28

9:00 a.m.	Registration.
10:30 a.m. to 12:30 p.m.	*Opening Convention Session.* Welcome by Dr. Albert W. Recht, director of Chamberlin Observatory, University of Denver. Arthur S. Leonard for the Western Amateur Astronomers (WAA), Walter H. Haas for the Association of Lunar and Planetary Observers (ALPO), Clinton B. Ford for the American Association of Variable Star Observers (AAVSO). Mrs. Grace Scholz Spitz for the Astronomical League (AL), "Amateur Astronomy – Its Development and Aims." Henry M. Corrado, "Growth of Amateur Astronomical Societies." Jane Gann, "From the Editor's Desk."
2:00 p.m.	*Field Trip to Boulder, Colorado.* Program at National Bureau of Standards and tour of radio telescope installations.
3:00 to 5:00 p.m.	Informal discussions of various topics by those remaining in Denver, in Science Halls.
7:00 p.m.	*Convention Banquet,* Student Union. Speaker: Dr. W. A. Rense, physics department, University of Colorado; motion pictures of his trip to Russia for International Astronomical Union meeting in 1958, including visits to Samarkand and Tashkent; research on ultraviolet solar radiation by means of rockets.

Saturday, August 29

8:30 to 10:00 a.m.	*General Session.* Chairman: George Perkins, WAA. Henry Selters, "Arguments on Behalf of Space Travel." Capt. C. Adair, "Vacationing in Outer Space." Dr. Clarence P. Custer, "Little Known Facts, Records, and Pictures." Dr. Earle G. Linsley, "The Old Astronomical Instruments on the Wall in Peiping, China."
10:00 a.m.	Group Photograph.
10:45 a.m. to noon	*General Session* (continued). Pascal M. Rapier, "A Philosophy of Modern Cosmology." Thomas A. Cragg, "A Study of a Solar Observer's k-Factor During a Sunspot Cycle." Mr. Cragg will then show time-lapse motion pictures of the planets Mars, Jupiter, and Saturn, taken by Robert Leighton, California Institute of Technology, with the 60-inch reflector of Mount Wilson Observatory.
1:00 p.m.	*Field Trip to Colorado Springs.* Tour of Air Force Academy and Planetarium, and chuck-wagon dinner at Garden of the Gods. No evening activities scheduled in Denver.

Sunday, August 30

9:30 to 10:30 a.m.	*Junior Session.* Chairman: Kay Gross, AL Junior Group. Seven talks by juniors, on an amateur observatory, the ashen light of Venus, Cepheid variables, stellar evolution, the 1958 eclipse, an astrocamera, and telescope making.
10:40 a.m. to noon	*General Session.* Chairman: Armand N. Spitz. Mrs. Gann, "Catching Satellites with Clock and Camera." Walter A. Munn, "Moonwatch Contributions." Vaughn Richardson, "Satellite Mathematics for High School Seniors." Charles A. Federer, Jr., "A Dozen Hints on Constellation Study."
1:30 to 2:50 p.m.	*General Session.* Chairman: Chandler H. Holton, AL. Walter Scott Houston, "Electronics in Amateur Astronomy." Thomas R. Cave, Jr., "Your Telescope and Mine." George T. Keene, "Astrophotography with a 12-inch Reflector." Jack Eastman, Jr., "Lunar and Planetary Photography."

3:00 to 4:00 p.m.	*General Session.* Chairman: Mr. Haas. William E. Shawcross, "The ALPO Photo-Duplication Service." K. H. Engle, "The Figure of the Moon." Dr. Linsley, "Hawaiian Volcanos and the Moon." Ernst E. Both, "The Moon and Mars – Contributions of the Amateur." Leonard B. Abbey, Jr., "The Nomenclature of Mars and the IAU."
4:00 to 5:00 p.m.	*Separate Business Meetings.* AAVSO, AL, ALPO, and WAA.
6:00 p.m.	*Public Exhibit and Star Party.* On Chamberlin Observatory park lawn; inspection of 20-inch refractor.

Monday, August 31

8:30 to 10:30 a.m.	*Planetary Observing Session.* Chairman: Mr. Haas. Mr. Cave, "The Amateur Mars Observer and Some Notes on the 1958 Apparition." Joseph S. Miller, "Observing the Blue Clearing of Mars with a Photoelectric Photometer." Dale P. Cruikshank, "Observations of Venus and Mercury with Large Apertures." Phillip W. Budine, "Valuable Amateur Studies of Jupiter." Mr. Haas, "Discussion of a Note by Takeshi Sato on the South Equatorial Belt Disturbance on Jupiter." David D. Meisel, "A Method of Visual Cometary Photometry."
10:40 to noon	*Variable Star Observing Session.* Chairman: Mr. Ford. J. J. Ruiz, "Photoelectric Program of the AAVSO." David Warshaw, "Report on AAVSO's SEA Program to Date." Mr. Cragg, "The Irregular Variable Star XZ Aurigae." L. J. Robinson, "Variable Stars Within the Orion Nebula."
1:00 to 3:00 p.m.	*General Session.* Chairman: Mr. Ford. Dr. James W. Warwick, "The Extended Hydrogen Atmosphere of the Sun: H-II Region or Corona?" William H. Glenn, "Observing the October, 1959, Eclipse." Dr. Walter L. Moore, "Three Power Supplies for Use with the Photoelectric Photometer." Mr. Miller and Paul Roques, "Photoelectric Patrol Methods for Flare Stars." Mr. Glenn, "The Conversion of Altitude and Azimuth Measurements to Right Ascension and Declination."
3:00 to 3:30 p.m.	*Final Session.* Announcements.
7:00 p.m.	*Final Banquet,* Student Union. Principal speaker: Thomas A. Cragg, Mount Wilson Observatory, "Trials and Tribulations of an Astronomer." Presentation of the G. Bruce Blair award to Earle G. Linsley, former director of Chabot Observatory, Oakland, California, by Western Amateur Astronomers. AL award. Re-run of Leighton movies of planets from Saturday morning general session.

Tuesday, September 1

9:30 a.m.	*Field Trip to Climax, Colorado.* High Altitude Observatory will be visited, on 220-mile round trip, with second and third groups leaving at 11:30 a.m. and 1:30 p.m., respectively.

General Information

The registration fee for the convention is $2.50 per person and $3.50 for a family. A complete package of tickets for the three field trips costs $11.00 per person. Each tour is by chartered bus only. Tickets for the individual trips are also available: to the National Bureau of Standards, $1.75; to the Air Force Academy, $5.75; to the High Altitude Observatory, $4.25. For each of the two banquets, the price is $3.00.

Housing accommodations are: single beds in two-bed rooms, $3.00 a day per person; one-bedroom apartments, with an average of three beds per unit, $7.00 per day; two-bedroom apartments, for five or six, $10.00 a day.

All fees and reservations may be sent to Ned Onstott, 2421 Second Ave., Pueblo, Colo.

Thomas A. Cragg, a banquet speaker at the Denver convention, is here at work in the spectroheliograph room at the foot of Mount Wilson Observatory's 60-foot solar tower. His right hand rests on the controls for the dome, coelostat mirror, drive and drive-rater, and master switch for the top of the tower. His left hand adjusts the micrometer for centering the first selector slit on the desired spectral line, and he is looking at a small bright image formed by a long-focus lens for the automatic guiding device.

MIDDLE EAST CONVENTION

TEN societies were represented by the 80 amateurs attending the Middle East regional convention of the Astronomical League on May 9th. It was held at the du Pont Country Club in Wilmington, Delaware, with the Delaware Astronomical Society as host.

During the formal session, eight papers were presented, followed by two round-table discussions. That evening the banquet speaker was Hector Fernandez Guido, director of the Municipal Planetarium, Montevideo, Uruguay. The day-long affair was concluded with the motion picture, The Story of Palomar, and a star party.

Regional officers for the coming year are Beaufort Ragland, Richmond, Virginia, chairman; David Meisel, Fairmont, West Virginia, vice-chairman; Edward Naylor, Harrisburg, Pennsylvania, treasurer; and the undersigned, secretary.

EMIL VOLCHECK, JR.
21 Lowry Dr.
Wilmington 5, Del.

NEW ALPO ADDRESS

After August 1st, the address of the Association of Lunar and Planetary Observers and of its magazine, the *Strolling Astronomer,* will be Pan American College Observatory, Edinburg, Tex.

Walter H. Haas, director of the ALPO, has accepted a teaching position at Pan American College. He is joining its astroscience group, headed by Prof. Paul R. Engle, who built the main telescope of the college's observatory, a 17-inch Newtonian-Cassegrainian reflector.

AMATEUR MEETS AMATEUR

The April, 1957, issue of Sky and Telescope (page 301) carried a fine meteor photograph taken by Walter Palmstorfer of Pettenbach, Austria. In his report, he asked American amateurs to write him, an invitation I accepted. Our exchange

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For 7" diameter tube	7.95	"
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COMPLETE PARTS and instructions for building the 6" Cleveland, except optical parts	129.75	f.o.b.
6" PYREX MIRROR f/8 1/10 wave, parabolic, beryllium coated, with matching 1/10 wave, 1.25" x 1.77" diagonal	67.50	ppd.

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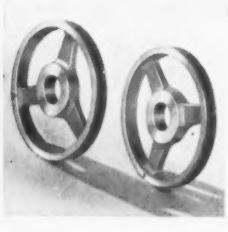

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CLEVELAND ASTRONOMICS

BOX 209, CHAGRIN FALLS, OHIO

of letters has been rich and rewarding.

During a European trip last May, my wife and I visited Mr. Palmstorfer and his small family. He is the postmaster of his village, which is about 25 miles south-southwest of Linz, Oberösterreich.

The Austrian amateur is active in the Gmunden Union, a flourishing astronomical society started by Professor Eisner of Gmunden University. Mr. Palmstorfer serves the group as translator of American astronomical papers.

E. J. ANDREWS
2262 N. Church St.
Decatur, Ill.

AMARILLO, TEXAS

There are 12 adult and 10 junior members in the Panhandle Astronomical Society. The president is William McEachern, 3206 W. Lawn, Amarillo, Tex.

ROCKFORD, ILLINOIS

In addition to a junior society, there is a senior group in Rockford, Illinois, which was formed by amateurs originally belonging to the Beloit Astronomical Society. The 22 active members of the Rockford Amateur Astronomers meet monthly on the third Wednesday at 7:30 p.m. A. Reyner Eastman, 1004 Rockford Trust Bldg., is the corresponding secretary.

SCRANTON, PENNSYLVANIA

The Lackawanna Astronomical Society is comprised of 15 amateurs. Meetings are held every other Thursday at 7:30 p.m. in the Everhart Museum. Interested persons should contact Christopher Ray, Everhart Museum, Scranton 10, Pa.

BEACON, NEW YORK

There are 21 adult members in the Texaco Astronomy Club, which meets biweekly at the Texaco Research Center, Glenham, New York. More information is available from F. C. McCoy, 48 W. Willow St., Beacon, N. Y.

BABYLON, NEW YORK

Founded about six years ago by five amateurs, the Long Island Observers' Association has now grown to 24 members. The club meets each Wednesday at the home of its president, John Tosto, 8 Bacon Lane, Babylon, N. Y.

A monthly feature is an astronomy class conducted by Walter Huebner, former head of the department of geography and geology at Luckan Junior College in Germany. Professor Huebner has written several articles and books in his field, and is currently working on a book to be titled *A Popular Astronomy from A to Z.*

Other meetings are given over to astronomy discussions, films, invited speakers, telescope making, and observing through the club's 12½-inch reflector. More information is available from Beatrice L. Witham, 84 Bay Dr., Massapequa, N. Y.

OBSERVER'S PAGE

Universal time (UT) is used unless otherwise noted.

Suggestions for October Eclipse Observations

MANY amateur astronomers are making plans to observe the total eclipse of the sun on Friday morning, October 2nd. Totality can be seen in the United States only from a small area, all of it within about two hours driving time from Boston, Massachusetts. Detailed maps of this region appeared on pages 306 and 307 of the April issue, while a smaller-scale chart of the entire eclipse path, from New England to the Indian Ocean, can be found on page 200 of February. Other Sky and Telescope articles on the coming spectacle were in May (sketching the eclipse) and July (hints for photography).

In Massachusetts the sun rises already in eclipse, and at Salem, where the central line meets the Atlantic coast, totality begins at 5:50 a.m. Eastern standard time, with the sun barely one degree above the sea horizon. All planning for observing the eclipse is vitally affected by this very low altitude of the sun in the eastern sky. Careful selection of a site with an unobstructed horizon will be necessary to see totality.

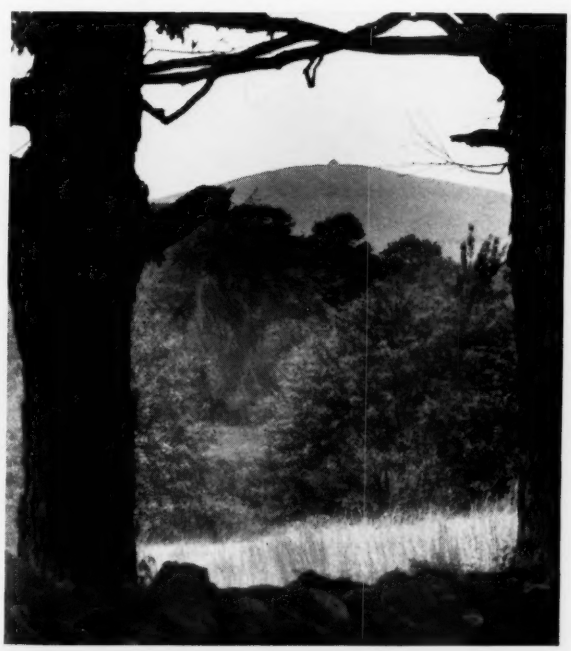
Another consequence of the lowness of the sun will be heavy atmospheric extinction, dimming the corona, and lessening the contrast between it and the sky. For these reasons, photographers in the path of totality may have more success in filming narrow-crescent phenomena, such as Baily's beads, than details of the corona.

Rev. George W. Walker, Buffalo, New York, points out that one advantageous observing site will be the summit of 2,108-foot Mt. Wachusett, about 13 miles southwest of Fitchburg. Although this is far enough inland to retard sunrise, as seen from ground level, by four minutes, at the top of the mountain the sun will come up four minutes earlier than at its foot, because of the dip of the horizon. Thus, these two effects cancel each other, and the sun will have the same altitude above the horizon at Salem and atop Mt. Wachusett as totality begins.

At that inland site, there will not be the same danger of sunrise fog as on the coast, but the depressed horizon may suffer seriously from haze, particularly as the direction to the sun will be over metropolitan Boston. The summit of Mt. Wachusett provides an unobstructed view in all directions: it is located in a Massachusetts state reservation and is readily accessible by good roads.

Reverend Walker writes: "As the sun arrives at the horizon, the part rising first will be completely blacked out by the moon, so that no direct sunlight will be visible for almost two minutes more. And if the eastern sky were sufficiently clear and darkened by the shadow effect, it might just be possible to see the corona rising ahead of the sun, although this pre-eclipse viewing has never yet been recorded. Observers can look for this up to the moment when the first direct sunlight comes over the horizon. Then there is no possibility of seeing the corona until totality itself occurs a few minutes later.

"When the bright lower edge of the sun appears over the horizon, it will be a very thin crescent, scarcely more than a short arc of the circle of the disk. At the moment of appearance for observers in central Massachusetts, the crescent will already be in the process of breaking up



A telephoto view of Mt. Wachusett, the highest site available to Massachusetts observers of the October 2nd total eclipse. The mountain may be approached by Route 31, 62, or 140. In this picture, taken from Route 140 near the Wachusett reservoir, the summit is about seven miles away. A 7-inch Aero-Ektar lens was used on a 35-mm. Exakta VXIIa camera. Photograph by Robert E. Cox.

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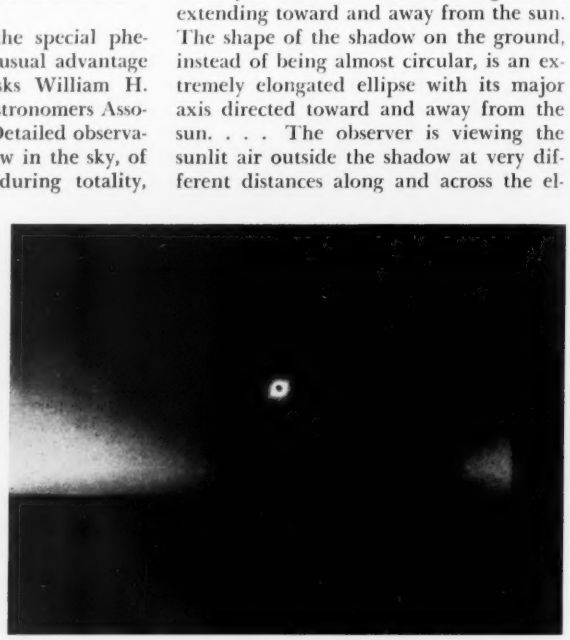
into Baily's beads, which are caused by sunshine passing through valleys at the edge of the moon.

"Very close to 5:49:50 EST, the last bead will disappear. The corona will immediately shine out, if the sky is very clear. Venus will shine brilliantly. Regulus and a few other stars will be visible in the darkened sky, but stars near the sun will require optical aid."

"Why not watch for the special phenomena to be seen to unusual advantage at a sunrise eclipse?" asks William H. Glenn, of the Amateur Astronomers Association, New York City. Detailed observations of the moon's shadow in the sky, of the degree of darkness during totality, and of sky coloration are all recommended.

He writes in the July issue of the AAA publication, *Eyepiece:* "During a sunrise eclipse such as the coming one, the moon's shadow . . . [extends] tangentially to the earth's surface at that time, and it will be seen first as a dim obscuration in the sky above the observer, along a line extending toward and away from the sun. The shape of the shadow on the ground, instead of being almost circular, is an extremely elongated ellipse with its major axis directed toward and away from the sun. . . . The observer is viewing the sunlit air outside the shadow at very different distances along and across the el-



At the June 30, 1954, total eclipse of the sun, Dan Davis, Jr., photographed the corona and the moon's shadow on the atmosphere, from a 72-foot fire tower near Spooner, Wisconsin. He used a Brownie Hawkeye camera and Super-XX film, exposed for five seconds.

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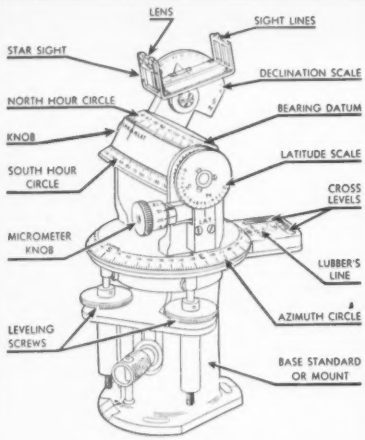

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lipse, with consequent variation in the appearance of the shadow in the sky. During totality the shadow can be seen in the direction of the sun as a truncated cone, narrower near the horizon, . . . while at right angles to the sun the sunlit air outside the shadow can be seen extending well above the horizon. As the total phase progresses, the appearance of the sky changes from moment to moment, and, at the end of totality, the shadow will have dropped below the horizon and the sky above the sun will be unobscured."

Relatively few photographs of this striking effect have been made, although only simple equipment is needed. For example, the picture on page 566 was obtained at the June 30, 1954, eclipse with a Hawkeye Brownie camera, using a five-second exposure on Super-XX film. Those who plan to photograph the shadow should note the exact time the exposure is made, with respect to the beginning or end of the total phase, since the shadow's aspect changes rapidly.

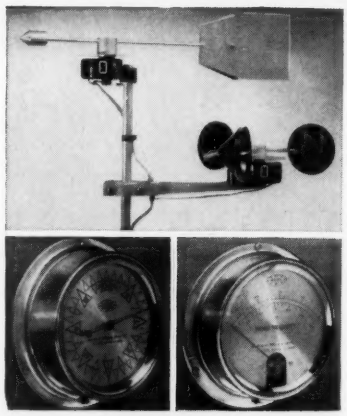
Careful descriptions of the shadow's visual appearance are very desirable, and make a high-priority project for naked-eye eclipse watchers. Reverend Walker writes: "Observers about six miles south of the center line of the eclipse will see the brighter unshadowed air equally distant to the north and to the south, and the darker sky directly above. This substantial cylinder of blackness will be about 33 miles in diameter, and one might almost be inclined to duck as it drops down from overhead."

Even if you are outside the path of totality, but within a few hundred miles of it, you may be able to see the shadow in the air at the time the eclipse is total in Massachusetts. The sun does not have to be above your horizon. From New York City, the shadow would appear in the northeastern sky before sunrise, and from Albany it may be seen passing rapidly from west to east across the heavens.

Mr. Glenn suggests that observers note the color of the moon during totality—a neglected type of observation. He found at the 1954 eclipse that the moon appeared slate blue, like the nearby sky but much darker. One description at the 1937 eclipse was "grayish blue with brown center," and some old reports mention a purplish hue.

Shadow bands are another phenomenon worth viewing in the minute or two just before and after totality, when the sun is a very narrow crescent. At that time the bands may be visible as dim, parallel ripples of light and shade, moving across areas illuminated by the sun. At other eclipses, with the sun high in the sky, shadow bands are best seen on white screens on the ground, but for a sunrise eclipse the target should be a vertical white surface, facing east, and several feet across.

The appearance of the bands, as well as the speed and direction of their mo-



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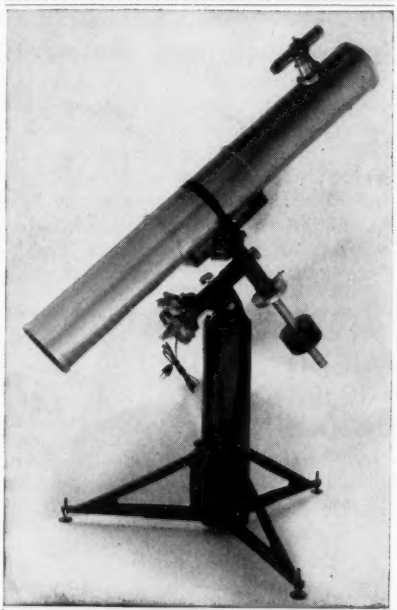

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tion, should be carefully noted by anyone fortunate enough to see them. These characteristics differ greatly from eclipse to eclipse, as well as depending on the observer's location. A good photograph or motion picture of the shadow bands at the coming eclipse will be an unusual and possibly unique record.

Explanation of the shadow bands is controversial. Although generally attributed to refraction effects from irregularities in air density, the bands are a diffraction phenomenon, according to Richard L. Feldman, Falls Church, Virginia, who has made an extensive study of them. On his interpretation, the orientation of the bands should be tangent to those portions of the edge of the shadow that sweep past the observing point.

SUNSPOT NUMBERS

The following American sunspot numbers for May have been derived by Dr. Sarah J. Hill, Whitin Observatory, Wellesley College, from AAVSO Solar Division observations.

May 1, 117; **2,** 119; **3,** 103; **4,** 97; **5,** 90; **6,** 128; **7,** 131; **8,** 129; **9,** 173; **10,** 220; **11,** 199; **12,** 240; **13,** 234; **14,** 197; **15,** 182; **16,** 142; **17,** 157; **18,** 159; **19,** 125; **20,** 137; **21,** 114; **22,** 118; **23,** 121; **24,** 134; **25,** 138; **26,** 129; **27,** 137; **28,** 93; **29,** 80; **30,** 80; **31,** 104. Mean for May, 139.6.

Below are mean relative sunspot numbers for June by Dr. M. Waldmeier, director of Zurich Observatory, from observations there and at its stations in Locarno and Arosa.

June 1, 152; **2,** 133; **3,** 148; **4,** 166; **5,** 162; **6,** 180; **7,** 181; **8,** 177; **9,** 172; **10,** 160; **11,** 172; **12,** 176; **13,** 165; **14,** 170; **15,** 158; **16,** 172; **17,** 161; **18,** 174; **19,** 182; **20,** 173; **21,** 162; **22,** 170; **23,** 188; **24,** 157; **25,** 184; **26,** 184; **27,** 184; **28,** 160; **29,** 158; **30,** 147. Mean for June, 167.6.

AURORAS IN JUNE AND JULY

An aurora was seen briefly on the night of June 23rd by New Jersey and New York amateurs. The earliest sighting, at 9:45 p.m., Eastern standard time, was by Thomas Mankiewicz, Bloomfield, New Jersey, who reported rays coming from a pale green arc on the northern horizon.

Two New York observers, Joseph A. Keane, Schenectady, and Blair Lewis, Auburn, saw patches and arcs at 10 o'clock. Lawrence Heilos, Jr., Millington, New Jersey, saw rays and patches, the aurora being predominantly red. By 10:30 the display was over.

On July 4th, Charles D. Naylor, Norristown, Pennsylvania, noted an aurora beginning at 9:20 p.m. EST. It was a silvery arch crossing the sky from northeast to southwest. The southeast part was nearly 10° wide and many times brighter than the Milky Way. The display vanished abruptly at 9:50. Mr. Naylor points out that two large sunspot groups were nearly central on the solar disk on this date.

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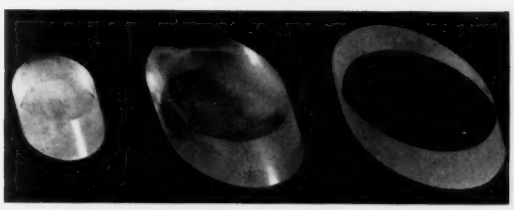

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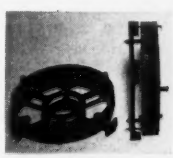

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Solid cast aluminum, fully adjustable, painted, complete and ready to use. Shipped postpaid.

6" mirror cell for 7" or larger tube	.....	$ 6.75
8"	"	9¼"	"	.....	8.95
10"	"	11¾"	"	.....	15.95
12½"	"	14½"	"	.....	20.95

BULK GRINDING ABRASIVES

This fast-cutting aluminum oxide has shaped grains that bite into the work for minimum grinding effort. It is tougher and stands up longer under severe usage. Excellent for both hand- and machine-grinding. Individually packaged quantities for shipment.

Grain size	5 lbs.	25 lbs.	50 lbs.	100 lbs.
#60	$2.25	$10.00	$16.00	$25.00
#150	2.50	11.25	19.00	35.00
#220	2.85	13.00	23.00	40.00

All quantities shipped express collect.

Write for free catalogue.

NYE OPTICAL CO.
2100 Cherry Avenue, Long Beach 6, Calif.
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Store hours: Daily, 9 a.m.-5:30 p.m.; Saturday, 9 a.m.-2 p.m.

NOW for a mere $55 down— YOU can own this UNITRON

Here is one of the most popular refracting telescopes for the amateur astronomer who wishes to combine both visual observation and astrophotography. Optically excellent, this instrument also has the very precise mechanical adjustments so essential for serious work. And the low 10% down payment is well within the average budget.

Model 145 is supplied complete with equatorial mounting and slow-motion controls, tripod, 2.4" photographic guide telescope with star diagonal and crosshair eyepiece, 10x 42-mm. view finder, 6 eyepieces, choice of UNIHEX Rotary Eyepiece Selector or Star Diagonal and Erecting Prism System, sun projection screen, sunglass, UNIBALANCE tube assembly, cabinets, and so forth, all for only $550. Extra eyepieces are available to permit a total of nine magnifications ranging from 30x to 300x.

If your interest lies only in visual observation, then we suggest UNITRON Model 142, the regular 3" Equatorial, priced at only $435 complete (down payment $43.50).

There is a UNITRON 3" Altazimuth model for as little as $265, complete, and other UNITRON Refractors are priced as low as $75. All may be purchased for only 10% down using our Easy Payment Plan. Whichever model you choose, you are assured of obtaining the finest instrument in its class.

After all, like thousands of others, you can place your confidence in UNITRON.

See the back cover.

3-inch PHOTO-EQUATORIAL

ACCESSORIES to Modernize Your Telescope

Many of the accessories and components pictured on Model 145 are available separately, to fit telescopes of various sizes.

ASTRO-CAMERA 220: complete with accessories	$ 69.50
PHOTOGRAPHIC GUIDE TELESCOPE: with brackets and accessories	75.00
VIEW FINDER: 10x, 42-mm. with mounting brackets	18.00
EQUATORIAL MOUNTING and TRIPOD: with cabinet	198.00
UNIHEX ROTARY EYEPIECE SELECTOR: for rapid change of eyepieces	24.75
UNICLAMP CAMERA BRACKET: for 3" refractor	3.75
OBJECTIVE LENS: 3", coated, air-spaced, in cell	69.00
RACK-AND-PINION MECHANISM: with drawtube	Prices from $12.50

UNITRON INSTRUMENT DIVISION of UNITED SCIENTIFIC CO.
204-206 MILK STREET BOSTON 9, MASSACHUSETTS

Be Certain of Optical Excellence – Choose UNITRON

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2" SATELLITE ($7.50 Down) 6x, diagonal eyepiece, altazimuth mount with circles, stand — **$75**

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2.4" ALTAZIMUTH ($12.50 Down) with eyepieces for 100x, 72x, 50x, 35x — **$125**

2.4" EQUATORIAL ($22.50 Down) with eyepieces for 129x, 100x, 72x, 50x, 35x — **$225**

3" ALTAZIMUTH ($26.50 Down) with eyepieces for 171x, 131x, 96x, 67x, 48x — **$265**

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3" PHOTO-EQUATORIAL ($55.00 Down) with eyepieces for 200x, 171x, 131x, 96x, 67x, 48x — **$550**

4" ALTAZIMUTH ($46.50 Down) with eyepieces for 250x, 214x, 167x, 120x, 83x, 60x — **$465**

4" EQUATORIAL ($78.50 Down) with eyepieces for 250x, 214x, 167x, 120x, 83x, 60x, 38x — **$785**

4" PHOTO-EQUATORIAL ($89.00 Down) with eyepieces for 250x, 214x, 167x, 120x, 83x, 60x, 38x — **$890**

4" EQUATORIAL with clock drive **($98.50 Down)**, Model 160V, eyepieces as above — **$985**

4" EQUATORIAL with clock drive and metal pier **($107.50 Down)**, Model 166V, eyepieces as above — **$1075**

4" PHOTO-EQUATORIAL with clock drive and Astro-camera **($117.50 Down), with eyepieces** for 250x, 214x, 167x, 120x, 83x, 60x, 38x, 25x — **$1175**

4" PHOTO-EQUATORIAL with clock drive, pier, Astro-camera **($128.00 Down)**, eyepieces for 375x, 300x, 250x, 214x, 167x, 120x, 83x, 60x, 38x, 25x — **$1280**

6" EQUATORIAL with clock drive, pier, 2.4" view finder, with eyepieces for 625x, 500x, 416x, 357x, 277x, 200x, 138x, 100x, 62x, 42x — **$5125**

6" PHOTO-EQUATORIAL as above but with 4" guide telescope, illuminated diagonal, UNIBALANCE, Astro-camera Model 330 — **$5660**

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Use Our EASY PAYMENT PLAN

UNITRON's popular Easy Payment Plan is a convenient and economical way to buy your UNITRON Refractor when you do not want to disturb your savings or when you haven't the total cost of the telescope immediately available. The down payment required is 10%. The balance due is payable over a 12-month period, and there is a 6% carrying charge on the unpaid balance. Your first payment is not due until 30 days after you receive the instrument, and if you should want to pay the entire balance due at that time, the carrying charge is canceled. (6" models available on special plan.)

There is no "red tape" when you order — you merely fill in the UNITRON Easy Payment Order Form, return it together with the required down payment, and the model of your choice is shipped to you at once.

Do not hesitate to use this plan merely because you have never before purchased anything on time payments. The procedure is practically painless and is an ideal means of enjoying the use of your UNITRON while paying for it.

HOW TO ORDER

Send check or money order in full or use our Easy Payment Plan, as described above. Shipments made express collect. Send 20% deposit for C.O.D. shipment. UNITRON instruments are fully guaranteed for quality, workmanship, and performance, and must meet with your approval or your money back.

There is much to recommend a UNITRON Refractor as the logical choice for the amateur astronomer. A UNITRON, optically speaking, duplicates the performance of larger telescopes of other types. With its long focal length, higher magnifications of planetary and lunar images are obtained with low-power eyepieces. Moreover, there are no mirrored surfaces to become oxidized, no components which require periodic alignment, no secondary optics to cause diffraction patterns, and no folding of the light back on itself through turbulent air with consequent loss of definition. No wonder that you see more and see better with a UNITRON — the telescope that has withstood the test of time.

Note These UNITRON Features

- LENSES are FULLY CORRECTED for spherical and chromatic aberration and are COATED for maximum brilliance and clarity of image. Optics especially designed for astronomical observation. AIR-SPACED OBJECTIVES.
- REFRACTOR type of design duplicates the performance of larger telescopes of other types. No mirrored surfaces to become oxidized. Superior definition to the very edge of the field.
- EYEPIECES of the HIGHEST QUALITY: Orthoscopic, Achromatized Symmetrical, Kellner, Huygens. Three to ten eyepieces included with each instrument.
- FINEST MATERIALS used throughout. DURALUMIN TUBE. Moving parts of BRASS carefully machined to close tolerances, and finished in CHROMIUM. No war-surplus components used.
- MODERN DESIGN based on time-tested engineering principles. HANDSOME APPEARANCE to which no illustration can do justice.
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- ALTAZIMUTH MODELS have slow-motion controls for **both** altitude and azimuth as well as clamps for both co-ordinates. Sturdy TRIPOD.
- VIEW FINDER with crosshair eyepiece.
- RACK-AND-PINION FOCUSING.
- Choice of UNIHEX Rotary Eyepiece Selector or STAR DIAGONAL and ERECTING PRISM for TERRESTRIAL OBSERVATION. The same complete range of terrestrial magnifications as for celestial observation.
- SUNGLASS for solar observation.

Higher- and lower-power eyepieces available for all models. Prices include basic accessories, tripod and mounting, fitted wooden cabinets, and operating instructions. Additional accessories available to add further to your observing pleasure.

UNITRON's Popular VIEW FINDERS

1. (As used on UNITRON 2.4" Models): 23.5-mm. (.93") achromatic objective, 6x eyepiece with crosshairs. Chromed brass tube. Mounting brackets with centering screws.

Only $8.50 postpaid

2. (As used on UNITRON 3" Refractors): 30-mm. (1.2") coated achromatic objective and 8x eyepiece with crosshairs. Other details as in View Finder 3.

Only $10.75 postpaid

3. (As used on UNITRON 4" Refractors): 42-mm. (1.6") coated achromatic air-spaced objective. 10x eyepiece with crosshairs. Duralumin tube finished in white enamel. Dewcap. Furnished with mounting brackets, centering screws for collimation, and mounting screws. This finder measures approximately 16" over-all. It is light in weight, compact and small enough for use as a hand telescope furnishing spectacular wide-field views of the sky.

Only $18.00 postpaid

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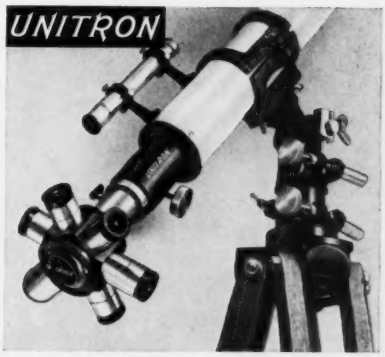
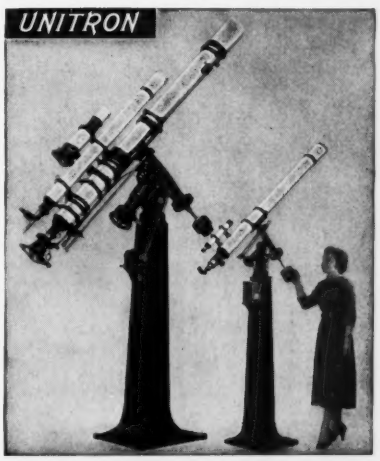


UNITRON 2.4" Altazimuth
America's most popular low-priced refractor



UNITRON 6" Photo-Equatorial
the logical choice for the serious observer and for the school and college observatory

UNITRON SATELLITE TELESCOPE
for the critical observer who wants the very best

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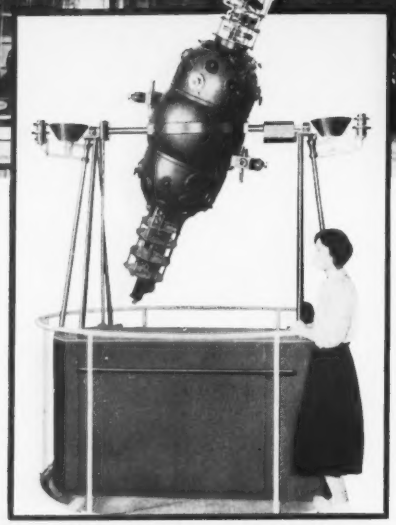
GOTO
TOKYO

Established in 1926, Japan's oldest and largest firm specializing in astronomical telescopes.

The Goto Planetarium Hall at the 1959 Tokyo International Trade Fair.



Goto's Model M-1 has been acclaimed by many visitors to the Fair, including specialists.

GOTO'S MEDIUM-SIZE PLANETARIUM

Goto Optical Mfg. Co., Japan's foremost maker of astronomical telescopes, is nearing completion of its revolutionary medium-size planetarium.

FEATURES :

1. Projects the entire celestial sphere and can show the sky above any point in the world. Therefore, the starry sky above various points south of the equator, particularly the Antarctic, can also be projected to the very last detail.
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Catalogues will be sent upon request.

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Famous Bausch and Lomb make, mint new. Kellner type with high eyepoint, clear flat-to-the-edge field. Balcoted throughout. Limited supply. Expect refund if late. Present comparable list price 3 to 4 times higher.
A. 37-mm. E.F.L.—$6.00; **B.** 24-mm. E.F.L.—$6.00; **C.** 17-mm. E.F.L.—$6.00; **D.** 9-mm. E.F.L.—$6.00; **E.** Animar model, 3-element, Balcoted, 12-mm. E.F.L., f/2.8 lens—$6.00.
Please remit payment with order.
Add 25¢ postage per ocular.
Bushings to fit your size tubing available.

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HELPFUL HINTS TO OBSERVERS!

The free literature offered in the Frank Goodwin ad below includes the following subjects: telescope observational techniques and methods; cutting down sunlight externally in viewing the sun; cleaning mirrors; sealing objectives against interelement air-space dewing; how to approximate off-axis performance with your reflector by a simple black-paper mask on mirror, occulting diffraction of diagonal and struts. (Also how the Goodwin Resolving Power lens is positively guaranteed to make any good telescope perform like a larger one, for reasons stated in the ad below.)

FRANK GOODWIN
345 Belden Ave., Chicago 14, Ill.

NEW THRILLS FROM YOUR TELESCOPE!

Sharper images, wider field, more light at higher powers! A startling statement positively proven in 16-page telescopic educational matter, plus many helpful hints, sent free on receipt of self-addressed long envelope with 12c return postage.

First, the Goodwin Resolving Power lens placed in front of eyepiece gives three times the magnification on each by increasing the effective primary focal length up to three times, yet extends eyepiece out no more than two inches from normal. This alone sharpens definition.

Next, by achieving your highest powers on more comfortable low-power eyepieces, you lessen image deteriorations due to short-focus acute bending of the convergent beam, since all usual eyepieces are f/1 or less. Again sharper images from this highest precision lens.

Third, you get greater illumination and wider field by relieving tiny aperture restrictions of higher-power eyepieces.

The Resolving Power lens is achromatic, coated, gives flat field sharp to the edge. Here is astonishment! Price $23.50 in 4" long adapter tube fitting standard 1¼" eyepiece holders ONLY. (Also adaptable to Unitrons; state if Unitron.) Money back if not positively thrilled after two weeks trial! Used and praised by legions!

No COD's—Colleges and Observatories may send purchase order.

FRANK GOODWIN
345 Belden Ave., Chicago 14, Ill.

The setting sun was photographed by Walter A. Feibelman, Pittsburgh, Pennsylvania, on May 7, 1959, showing its familiar elliptical shape near the horizon.

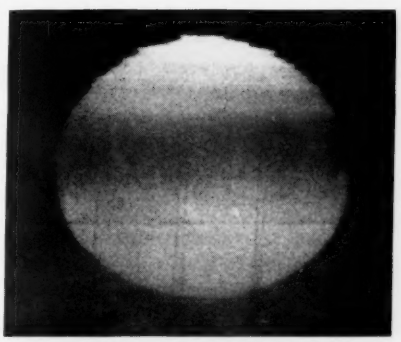
SUNSET PHENOMENA

On March 28, 1959, after completing a small telescope for solar photography, I used that instrument with a 10-power eyepiece to look at the sun when it was only about 2° above the horizon. The upper limb was encased in a bright green rim and the lower limb in a red one. The green color was particularly striking at the deep notches caused by stratification of the air. As the sun sank below a dense layer of clouds, intensely green portions of the upper limb were pinched off, about a dozen times in succession.

When the sun sets, there are three distinct phenomena (described and pictured in detail in the recent book, *The Green Flash and Other Low Sun Phenomena,* D. J. K. O'Connell, S. J., Interscience Publishers, Inc., New York, 1958). These are the green rim, the green segment, and the green flash, and the first two also occur at the lower limb in red. Near the horizon the sunlight must traverse a great thickness of the earth's atmosphere, and the air acts as a prism, dispersing the light. In addition, refraction produces the well-known elliptical shape of the low sun.

The colored rims are easily seen in a small telescope for 10 to 15 minutes before sunset or after sunrise.

WALTER A. FEIBELMAN
1063 Findley Dr.
Pittsburgh 21, Pa.



Mr. Feibelman's photograph just before sunset on May 31, 1959, showing the effects of stratifications in the air. These produced the notches on the edge of the solar disk.

SINCE 1933

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Reg. U.S. Pat. Off.

Let us give you the same hard aluminum coating that we are applying to the Cave Astrola mirrors. If your glass is properly polished, our coating will give a **minimum of 90% reflection.** Will not blister or peel. Check or money order, including return postage and insurance (Calif. res. add 4% sales tax), will guarantee **8 hours shipping service.** No C.O.D.'s please. Prices f.o.b. L.A.

6-inch	$6.50	10-inch	$11.25
8-inch	$8.50	12-inch	$16.00

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Research and Production Laboratories
2958 Los Feliz Blvd., Los Angeles 39, Calif.

Precision Diagonals

You will get the best possible performance from your telescope with one of our clear **fused quartz** diagonals. Accuracy guaranteed 1/20 wave.

Ellipse 1.25" x 1.77"	$12.00
Ellipse 1.5" x 2.12"	$15.00

Pyrex diagonals, 1/8-wave accuracy.

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Ellipse 1.5" x 2.12"	$ 9.00

Without aluminum coating, deduct $1.00.

Send for our complete list of supplies, quartz mirrors, blanks, oculars, coatings, and accessories.

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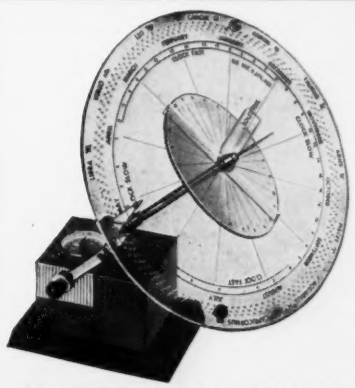
Minneapolis 13, Minn.



THE ASTRONOMICAL LOCATOR
is an instrument of many uses to teach or to study the solar system.

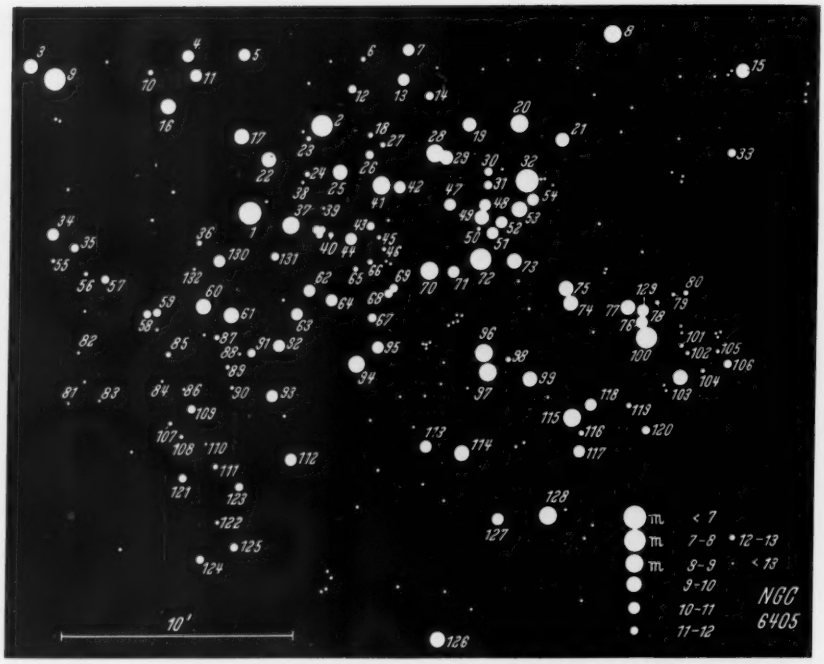
- By turning the large 12-inch disk with its apparent sun globule to any hour on the small dial, one can see readily what part of the sky is currently overhead and which constellations along the ecliptic are in view at night.
- The equation of time is clearly marked for each month throughout the year, and is always near the earth globule to show what adjustment in minutes is necessary to the sun or to the clock.
- Learn when and where to look for specific stars with the aid of this instrument. With booklet, "Of Time Space and the Locator," $36.00 Postpaid. Booklet only, $1.00

PREMIER PLASTICS CORP.
204 W. WASHINGTON ST., MILWAUKEE 4, WIS.

The Cluster Messier 6

LOCATED in the tail of Scorpius five degrees west of Gamma Sagittarii, the beautiful open cluster M6 is noteworthy for its large size and many bright stars. Also known as NGC 6405, its 1950 coordinates are right ascension $17^h\ 35^m.5$, declination $-32°\ 09'$.

The accompanying chart of M6 was prepared by the German astronomers K. Rohlfs, K. Schrick, and J. Stock, who measured the magnitudes and colors of the cluster stars with a photoelectric photometer attached to the 60-inch reflector at the Boyden Observatory in South Africa. For the numbered stars on the chart, the following list, from a paper by Dr. Rohlfs and his coworkers in the *Zeitschrift für Astrophysik, 47,* 15, 1959, gives yellow magnitudes, rounded off to the nearest 0.1.



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26, 11.8; **27,** 12.5; **28,** 8.8; **29,** 9.9; **30,** 11.5; **31,** 11.6; **32,** 6.8; **33,** 11.7; **34,** 10.7; **35,** 11.4; **36,** 12.6; **37,** 8.8; **38,** 13.2; **39,** 13.8; **40,** 12.8; **41,** 8.9; **42,** 10.6; **43,** 11.6; **44,** 10.6; **45,** 14.0; **46,** 14.9; **47,** 10.4; **48,** 10.6; **49,** 9.8; **50,** 13.8.

51, 10.0; **52,** 10.2; **53,** 9.8; **54,** 10.4; **55,** 13.1; **56,** 13.4; **57,** 11.8; **58,** 11.6; **59,** 11.1; **60,** 9.2; **61,** 9.7; **62,** 10.7; **63,** 10.2; **64,** 10.2; **65,** 12.6; **66,** 12.3; **67,** 11.3; **68,** 12.0; **69,** 12.0; **70,** 8.3; **71,** 10.2; **72,** 7.3; **73,** 9.9; **74,** 9.7; **75,** 9.9.

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101, 13.8; **102,** 13.6; **103,** 9.2; **104,** 13.5; **105,** 13.3; **106,** 11.4; **107,** 14.1; **108,** 13.0; **109,** 11.7; **110,** 14.2; **111,** 12.2; **112,** 10.8; **113,** 10.8; **114,** 9.8; **115,** 8.6; **116,** 12.4; **117,** 10.5; **118,** 10.9; **119,** 12.1; **120,** 11.1; **121,** 11.2; **122,** 14.5; **123,** 11.4; **124,** 11.2; **125,** 11.8.

126, 9.4; **127,** 10.3; **128,** 8.1; **129,** 10.2; **130,** 10.9; **131,** 12.0; **132,** 13.7.

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AMERICAN MADE — AVAILABLE NATIONALLY ON TIME PAYMENTS

★ For more than seven years we have provided optically parabolic mirrors for our own ASTROLA Reflecting Telescopes and separately for many hundreds of amateur telescope makers and observers. We also have always specialized in the refiguring or finishing of amateurs' mirrors for many hundreds of our customers.

★ Each and every mirror we produce is hand-corrected to an exceedingly high standard of figure. The final measure of quality of any telescope is its optical performance. Perhaps the ultimate test of any mirror is its ability to render identical **intrafocal** and **extrafocal** star images. We absolutely guarantee each mirror we make or refigure to meet this very exacting requirement. Each mirror and every ASTROLA reflector will give the Dawes limit of double star resolution, and will reveal a wealth of very fine detail on the moon and planets. The very high degree of optical polish and freedom from scratches and sleeks insures reaching the magnitude threshold for each aperture.

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NEW PARABOLIC PYREX MIRRORS AND REFIGURING

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6-inch	$ 60.00	$ 35.00
8-inch	$ 92.50	$ 50.00
10-inch	$160.00	$ 75.00
12½-inch	$250.00	$120.00

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	STANDARD	DE LUXE
6-inch	$325.00	$500.00
8-inch	$390.00	$590.00
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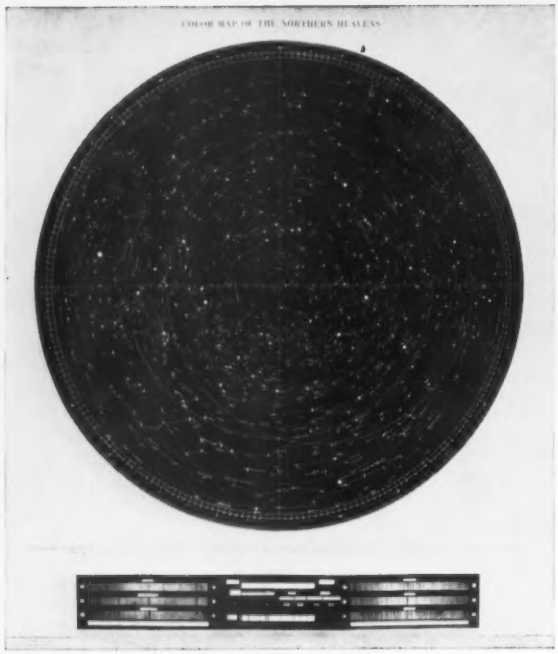

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BOOKS AND THE SKY

THE SLEEPWALKERS

Arthur Koestler. The Macmillan Company, New York, 1959. 624 pages. $6.50.

ALTHOUGH the author is best known for his novels and political essays, he has an interest in science dating back almost 30 years, when he was science editor of a German publishing house, Ullstein Verlag. In his novel *Darkness at Noon* (1941), the prisoner Rubashov, when asked what he would do if pardoned, answers, "Study astronomy." Evidently the author has taken this advice, for the present book shows an extensive background in this science and in the lives of great astronomers.

The work begins with a survey of ancient Greek astronomy. This is followed by biographical sketches of Copernicus, Tycho, Kepler, and Galileo, which make up almost 80 per cent of the whole book. There is a final chapter, "The Newtonian Synthesis," a philosophical epilogue, notes, bibliography, and index. Scattered through the volume are several chronological tables.

The Sleepwalkers is full of surprises, even for the initiated. Newton's first law of motion was almost discovered by the Occamist school of scholastic philosophers in 14th-century Paris (page 199). Galileo did not drop weights off the leaning tower of Pisa (page 429). Kepler's three laws were so scattered through his many writings that Newton deserves considerable credit for extracting and putting them together (pages 396, 398).

Koestler maintains an independent attitude toward his sources, using them for facts but reserving the right to form his own judgments of the scientific work and personal characters of historical figures. In the latter process, Kepler comes out well, Copernicus and Galileo badly.

During his last years, Copernicus worked intimately with a young German scholar, Rheticus, who wrote the first published account of the Copernican theory (*Narratio Prima*) and constantly encouraged publication of the main book. Nevertheless, when *De Revolutionibus* finally appeared, Copernicus included no reference to Rheticus' name. Copernicus revealed a similar churlishness in his correspondence with a fellow churchman, Bishop Dantiscus, from which our author concludes, "he really was an old sourpuss" (page 185).

The account of Galileo relies for many details on Santillana's *The Crime of Galileo,* but is quite different in tone. Koestler emphasizes the Florentine's grudging treatment of Kepler and says that his conflict with the Jesuits was avoidable. The Galileo affair was not typical of relations between the Roman Catholic Church and science (page 522).

There are a few errors and omissions. The diagram on page 67 shows a planet's epicyclic and deferential motions proceeding in the opposite sense; they should be in the same sense. The figure (page 505) showing the motion of an artificial satellite has the orbits D and E wrongly drawn; if a satellite travels more than 180 degrees in its orbit without intersecting the earth, it will complete its orbit and repeat it indefinitely, except for air drag and other perturbations. The explanation on page 506 is similarly incorrect. The statement (page 508) that the earth behaves gravitationally as if its whole mass were concentrated at its center would be true only if its mass were distributed in homogeneous spherical shells. The reference to "other novae between 125 B.C. and A.D. 1572" (page 290) can now be amplified by the new lists of ancient novae published from Chinese sources. One important item is missing from the notes and references, Lynn Thorndike's *History of Magic and Experimental Science.*

In his epilogue, Koestler tries to develop a philosophy of science. He discusses the conditions necessary for the growth of research and laments the modern divorce of science from faith and reality. Overspecialization is a cause of scientific decline, for example, Ptolemy's epicycles and modern quantum theory. Science owes its progress to the unsystematic, fortuitous discoveries of a few inspired men, the sleepwalkers.

The reviewer enthusiastically recommends this book. It is a product of sound scholarship and original interpretation.

CHARLES GASTEYER
Van Vleck Observatory

PHYSICS OF METEOR FLIGHT IN THE ATMOSPHERE

Ernst J. Opik. Interscience Publishers, Inc., New York, 1958. 174 pages. $3.85, cloth; $1.95, paper bound.

THIS compact account of the physical theory of meteors has been distilled from a series of lectures given by the author at the University of Maryland in 1957. To the expert in the field, terseness of expression, numerous short equations, and brief illustrative tables all commend the book as a most useful reference text.

Specialists may not concur with some of the author's interpretations and theories, which are occasionally expressed in terms so firm as to be dogmatic, but they must agree that even the contentious points cannot be dismissed lightly. Certainly there is nowhere else so complete and modern an account of the behavior of small high-speed particles in a rarefied gaseous medium.

The scientific layman, on the other hand, may do some head scratching when he encounters a statement or a principle introduced into the text with little or no explanation or referencing. Some background must be assumed in gas dynamics

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The Book was reviewed in the January issue of SKY AND TELESCOPE.

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and upper-atmosphere physics, obtainable from many available standard works, and which the author could furnish only by including a much more cumbersome (and costly) review of the stock in trade of the meteor physicist.

A short historical account of the astroballistic problems posed by the entry of small particles into our atmosphere is followed by a classification of meteors and their phenomena. Dr. Opik treats in detail how collisions with air molecules convert the meteor's kinetic energy into heat, light, and ionization. Exhaustive consideration is given to ablation of the meteoroid by vaporization, fusion and spraying of molten material, sputtering, and fragmentation. The role of atomic collisions is examined carefully, and it is shown how measurements of luminous output may be used to deduce meteor masses.

Air-impact relations are discussed for various types of meteoroids, going from large iron and stone objects down through the range of visible meteors to micrometeorites. Opik considers that all cometary meteors are of the "dust-ball" type — loosely bound aggregates of "stoneflakes" — a view for which there is increasing observational support.

One criticism is that the author appears to have ignored some of the more recent evidence from photographic and radio techniques. This does not imply that modern observations conflict seriously with Opik's theories. In fact, the new data do confirm many of his deductions, which are largely based on his own visual observing programs. But the reader may feel that adequate and explicit recognition has not been given to the radio work at Jodrell Bank and elsewhere, or to the Harvard photographic results.

With this reservation, this book by a well-known expert of many years standing is an essential reference for those engaged in meteor research, and for readers interested in the allied phenomena of rockets and earth satellites. For those who may have thought some of Opik's original papers to be rather heavy going — and this reviewer was one — this volume is remarkable for its clarity and concise exposition.

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A DIPPER FULL OF STARS

Lou Williams Page. Follett Publishing Co., Chicago, Ill., 1959. 223 pages. $2.95.

ALTHOUGH compiled primarily for junior high school levels, *A Dipper Full of Stars* presents an interesting, abundantly illustrated introduction to the heavens for nearly any beginner. The author's method of teaching the stars, in a sequence progressing from the widely known and easily identified Big Dipper (incorrectly termed a constellation), is a good one, even though it is not adhered to as the book progresses. For instance, Leo the Lion would be more easily located simply by looking beneath the Dipper's cup than "just west of Berenice's Hair," as suggested in Chapter 5.

The text of the first seven chapters deals with constellation identification, star lore, and explanations of the nature of nebulae, galaxies, and the like. It is written in an informal and easily readable style. Lou Williams Page is to be complimented on her ability to retell the myths and legends and at the same time present many sidelights on the stars. Concerning Orion alone, she weaves together the belief of the early Christians that his belt represented the three wise men, the astrological superstition that women born when Bellatrix is in the sky possess sharp tongues, and the story that great conquerors such as Alexander have decreed that the strikingly beautiful constellation be renamed after them.

The star charts accompanying these seven chapters are, for the most part, well done, their simplicity and uncluttered appearance making them effective and useful guides for the novice. Only in Fig. 52, showing the Pleiades, is there enough distortion to merit correction in a later edition.

Chapter 8, which deals with the solar system, tends to be sketchy on the various theories of lunar crater formation, the causes of the color changes on Mars, and the general nature of Jupiter's and Saturn's atmospheres. Unfortunately, a number of careless statements and obvious errors are included in this portion. The validity of the supposed radio bursts from Venus, reported in 1956, is controversial. Diagrams comparing the sizes of the planets indicate Mars and Earth as equal, whereas the former should have little more than half the earth's diameter. It is said that the moons of Saturn are small and can be seen only through a large telescope, but Titan is actually bigger than our own moon and can be seen easily with a small instrument. The reader is told, without factual basis, that meteorites have been known to kill men and destroy buildings.

However, the following chapter on man-made satellites, which has just been added to this new revision, is both informative and accurate. I am glad to see that some of the new popular astronomical works are at last giving the correct

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answers to such questions as, "What keeps a satellite up?"

Aside from the aforementioned weak spots, *A Dipper Full of Stars* will provide an enjoyable introduction and helpful guide to the sky for students, groups, and youth leaders. The author is to be commended for her easy style and frequent light touch which make reading the book fun, particularly for youngsters.

RAYMOND J. STEIN
Newark Museum Planetarium

DICTIONARY OF ASTRONOMY AND ASTRONAUTICS

Armand Spitz and **Frank Gaynor.** Philosophical Library, Inc., New York, 1959. 439 pages. $6.00.

THIS DICTIONARY gives definitions for some 2,200 terms and concepts related to astronomy and astronautics. Nearly all of the volume is devoted to astronomy, physics, and related fields, while the remaining entries come from present-day missile terminology.

The dictionary certainly could fill a valuable place in the popular literature as a source for rapid intelligence, but in its present condition it is dangerous to use due to a large number of errors. Upon glancing through the book this reviewer discovered more than a dozen mistakes, including very serious misdefinitions of such concepts as flux, flux density, and intensity.

The reviewer then investigated more carefully the A's, which comprise about 10 per cent of the volume. More than half a dozen additional errors were discovered. At this rate one might expect between 50 and 100 in the entire book. The reader is also disconcerted by a number of editorial mistakes and a frequently choppy and pedestrian style of writing.

It is to be hoped that a new edition of the dictionary will soon be forthcoming in which these errors and inconsistencies are rectified. In that case, it could be recommended as a worthy addition to any library.

DON A. LAUTMAN
Smithsonian Astrophysical Observatory

NEW BOOKS RECEIVED

INSIGHT INTO ASTRONOMY, *Leo Mattersdorf,* 1959, *Lantern.* 247 pages. $4.00.

This is the second edition of a book introducing astronomy to the layman. It differs from the first, published in 1952, by the addition of a chapter on rockets and satellites. The author is a past president of the Amateur Astronomers Association in New York City. The first edition was reviewed in SKY AND TELESCOPE for February, 1953.

SOUNDING ROCKETS, *Homer E. Newell, Jr.,* 1959, *McGraw-Hill.* 334 pages. $12.50.

A comprehensive and detailed account is given of the principal rocket types used in upper-atmosphere exploration and solar research. Emphasis is on handling and launching procedures, instrumentation techniques, and research results. There are many photographs and tables of specifications.

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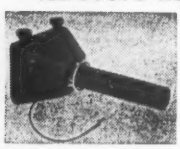

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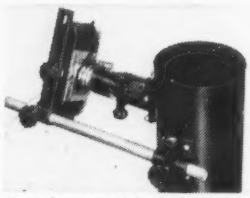
Bring distant objects 7 times nearer with a 35-mm. camera, 7 x 50 binocular, and our NEW BINOCULAR-TO-CAMERA HOLDER. Ideal for photographing the coming October eclipse of the sun, star clusters, the moon, as well as cloud formations, wild life, vistas. Camera and binocular attach easily. Use any binocular or monocular — any camera, still or movie. Take color or black-and-white. Attractive gray crinkle and bright chrome finish, 10" long. Full directions for making telephotos included.

Stock #70,223-Y.....**$11.50 ppd.**

Take Pictures Through Your Telescope with the EDMUND CAMERA HOLDER for TELESCOPES



Bracket attaches permanently to your reflecting or refracting telescope. Removable rod with adjustable bracket holds your camera over scope's eyepiece and you're ready to take exciting pictures of the moon. You can also take terrestrial telephoto shots of distant objects. Opens up new fields of picture taking!

SUN PROJECTION SCREEN INCLUDED

White metal screen is easily attached to holder and placed behind eyepiece. Point scope at sun, move screen to focus . . . and you can see sunspots!

All for the low, low price of $9.95

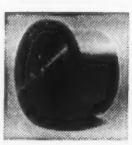
Includes brackets, 28¼" rod, projection screen, screws, and directions. Aluminum . . . brackets black crinkle painted.

Stock #70,162-Y.....**$9.95 ppd.**

Send check or money order — Money-back guarantee.

Mounted Ramsden Eyepieces

Standard 1¼" Diameter



Our economy model, standard-size (1¼" O.D.) eyepiece. We mounted two excellent quality plano-convex lenses in black anodized aluminum barrels instead of chrome-plated brass to save you money. The clear image you get with these will surprise you. Directions for using short focal length eyepieces are included with both the ¼" and ½" models.

Stock #30,204-Y....¼" focal length....$4.75 ppd.
Stock #30,203-Y....½" focal length....$4.50 ppd.

"TIME IN ASTRONOMY" BOOKLET

By Sam Brown. All about various kinds of time, contains sidereal timetable. How to use single- and double-index setting circles, how to adjust an equatorial mount, list of sky objects. Also includes 7" paper setting circles and stripes suitable for cutting out and mounting on plywood. Wonderfully illustrated.

Stock #9054-Y.....**60c ppd.**

ASTRONOMICAL TELESCOPE MIRRORS

Polished, Aluminized, and Over-coated

SPHERICAL MIRRORS

No.	Diam.	F.L.	Thickness	Price
30,219-Y	3"	18"	⅜"	$5.95 ppd.
50,082-Y	3"	30"	⅜"	7.65 ppd.
50,051-Y	4¼"	45"	⅝"	15.00 ppd.
70,168-Y	6"	72" (Pyrex)	1"	30.00 ppd.

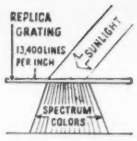
PARABOLIC MIRRORS (Pyrex)

No.	Diam.	F.L.	Thickness	Price
5002-Y	6"	48"	1"	$59.50 ppd.
85,069-Y	8"	64"	1⅜"	89.00 f.o.b.*
85,070-Y	10"	80"	1¾"	179.00 f.o.b.*
85,071-Y	12½"	100"	2⅛"	275.00 f.o.b.*

*f.o.b. Barrington, N. J.

REPLICA GRATING

Low, Low Cost



Take Unusual Color Photos at Night!

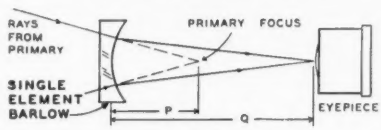
It's here — after decades of effort! Replica grating — on film — at very low price. Breaks up white light into full spectrum colors. An exciting display. 13,400 lines per inch. Spectrographs have been used to answer more questions about the structure of the material world and the universe than any other single device. Use it for making spectroscopes, for experiments, as a fascinating novelty. First time available in such a large size — so cheaply. Comes in clear plastic protector.

Stock #50,202-Y....Includes 2 pieces, 8" x 5½" — 1 transmission type, 1 reflection type....**$2.00 ppd.**

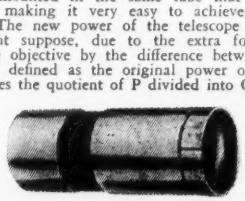
Stock #50,180-Y....1 piece, transmission type, 8 in. x 6 ft.....**$5.95 ppd.**

Stock #50,203-Y....1 piece, reflection type, 8 in. x 6 ft.....**$10.95 ppd.**

DOUBLE AND TRIPLE YOUR TELESCOPE'S POWER WITH A BARLOW LENS



WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power. The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q.



Beautiful chrome mount. We now have our Barlow lens mounted in chrome-plated brass tubing with special spacer rings that enable you easily to vary the power by sliding split rings out one end and placing them in other end. Comes to you ready to use. Just slide our mounted lens into your 1¼" I.D. tubing, then slide your 1¼" O.D. eyepieces into our chrome-plated tubing. Two pieces provided, one for regular focal length eyepieces and one for short focal length ones.

Stock #30,200-Y Mounted Barlow lens.....**$8.00 ppd.**

UNMOUNTED 3X BARLOW LENS

These lenses are made for telescopes that have smaller diameter eyepieces than the standard 1¼" size. Mount one between the eyepiece and objective, and triple your power. Instructions included. Single-element lens, focal length —1-5/16", unmounted.

Stock #30,185-Y....**0.932" diam.**.....**$3.50 ppd.**

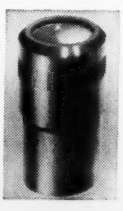
Stock #30,328-Y....**0.912" diam.**.....**$2.50 ppd.**

"MAKE-YOUR-OWN" 4¼" MIRROR KIT

The same fine mirror as used in our telescopes, polished and aluminized, lenses for eyepieces, and diagonal. No metal parts.

Stock #50,074-Y.....**$16.25 ppd.**

WAR-SURPLUS TELESCOPE EYEPIECE



Mounted Kellner Eyepiece, Type 3. Two achromats, focal length 28 mm., eye relief 22 mm. An extension added, O.D. 1¼", standard for most types of telescopes. Gov't. cost $26.50.

Stock #5223-Y.....**$7.95 ppd.**

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SALE! TERRIFIC WAR-SURPLUS BARGAINS!

AERIAL CAMERA LENSES

Big variety . . . at a fraction of Gov't. cost! f/6, 24" f.l., with diaphragm and lens cone. Used. Weight 25 lbs.
Stock #85,059-Y . . $39.50 f.o.b. Utah

Same as above, but new. Weight 25 lbs.
Stock #85,060-Y . . $59.50 f.o.b. Utah

f/8, 40" f.l., no mount or shutter. Weight 6¼ lbs.
Stock #70,186-Y . . . . . $49.50 ppd.

f/5.6, 20" f.l., telephoto with shutter and diaphragm. Weight 6¼ lbs.
Stock #70,187-Y . . . . . $65.00 ppd.

f/4.5, 6⅜" f.l., with shutter and diaphragm. Weight 1 lb., 6 ozs.
Stock #70,189-Y . . . . . $24.50 ppd.

These lenses are being successfully used for wide-aperture Moonwatch telescopes to see the small and fainter satellites. For eyepiece use our GIANT ERFLE.

8" SETTING-CIRCLE SET

Two 8"-diam. dials accurately printed on 1/16" thick black plastic, rigid and unbreakable. White figures on black background. Alternate black-and-white blocks designate divisions, allow easier reading — less eyestrain. ¼" pivot hole in center. Declination circle has 360° divided into 1° intervals, and reads from 0 to 90 to 0 to 90 to 0. Right-ascension circle has 24-hour scale divided into 5-minute blocks with two different scales on the same side. One reads from 0 to 6 to 0 to 6 to 0 hours and the other 0 to 24 hours consecutively. Instruction sheet included.

Stock #50,133-Y . . . . Complete set . . . . . **$3.00 ppd.**
Stock #60,078-Y . . . . 360° declination circle only **$1.60 ppd.**
Stock #60,079-Y . . . . 24-hour right-ascension circle only **$1.60 ppd.**

5¾" SETTING-CIRCLE SET

Same as described above but with 5¾"-diam. dials.
Stock #50,190-Y . . . . Complete set . . . . . **$2.50 ppd.**
Stock #60,080-Y . . . . 360° declination circle only **$1.35 ppd.**
Stock #60,081-Y . . . . 24-hour right-ascension circle only **$1.35 ppd.**

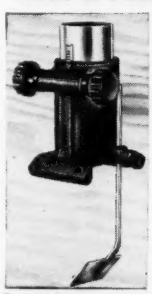
EQUATORIAL MOUNT and TRIPOD with CLOCK DRIVE

Heavy-duty mount. Drive operates on 110-volt, 60-cycle, a.c. house current. Follows motion of stars smoothly. 32" tripod legs included.
Stock #85,081-Y . . . . . $76.50 f.o.b. Barrington, N. J.

Same mount as above, without clock drive, for 8" or smaller reflectors and for 4" or smaller refractors.
Stock #85,023-Y . . . . . New Low Price . . . . . **$39.50** f.o.b. Barrington, N. J.

MOTORIZED CLOCK DRIVE (by itself) easily attached to your own mount. Instructions included.
Stock #50,198-Y . . . . . $36.95 ppd.

Rack & Pinion Eyepiece Mounts



Real rack-and-pinion focusing with variable tension adjustment; tube accommodates standard 1¼" eyepieces and accessory equipment; lightweight aluminum body casting (not cast iron); focusing tube and rack of chrome-plated brass; body finished in black wrinkle paint. No. 50,077-Y is for reflecting telescopes, has focus travel of over 2", and is made to fit any diameter or type tubing by attaching through small holes in the base. Nos. 50,103-Y and 50,108-Y are for refractors and have focus travel of over 4". Will fit our 2⅞" I.D. and our 3⅞" I.D. aluminum tubes, respectively.

For Reflectors
Stock #50,077-Y (less diagonal holder) $8.50 ppd.
Stock #60,049-Y (diagonal holder only) 1.00 ppd.

For Refractors
Stock #50,103-Y (for 2⅞" I.D. tubing) 12.95 ppd.
Stock #50,108-Y (for 3⅞" I.D. tubing) 13.95 ppd.

3-inch Astronomical Reflector

60 to 160 Power
An Unusual Buy!

Assembled — ready to use! See Saturn's rings, the planet Mars, huge craters on the moon, star clusters, moons of Jupiter, double stars, nebulae, and galaxies! Equatorial-type mounting with locks on both axes. Aluminized and over-coated 3"-diameter f/10 primary mirror, ventilated cell. Telescope comes equipped with a 60X eyepiece and a mounted Barlow lens, giving you 60 to 160 power. A finder telescope, always so essential, included. Sturdy, hardwood, portable tripod.

Free with scope: Valuable STAR CHART and 272-page ASTRONOMY BOOK.

Stock #85,050-Y . . . . . $29.95 ppd.

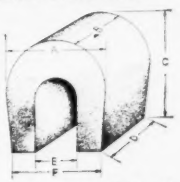
8-POWER ELBOW TELESCOPE

War Surplus — Amazing Buy!
$200 Gov't. Cost—Only $13.50

Big 2" objective, focusing eyepiece 28-mm. focal length, Amici erecting system, turret-mounted filters of clear, red, amber, and neutral, reticle illumination. Sparkling, clear, bright image — 6° field (325 ft. at 1,000 yards). Focus adjusts 15 ft. to infinity. Eyepiece alone, 28-mm. focal length, is worth more than $12.50.

Stock #70,173-Y . . . . . $13.50 ppd.

GIANT MAGNETS! TERRIFIC BARGAINS!



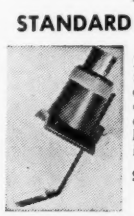
War surplus — Alnico V type. Horseshoe shape. Tremendous lifting power. 5 lb. size. Its dimensions: A — 3¼"; B — 2¾"; C — 4-3/16"; D — 1¼"; E — 1¼"; F — 2⅝". Strength is about 2,000 gauss. Will lift over 125 lbs.

Stock #70,183-Y . . . . . $8.50 ppd.

15¾-lb. size magnet. Approximately 5,000-6,000-gauss rating. Will lift over 250 lbs.

Stock #85,088-Y . . . . . $22.50 f.o.b. Barrington, N. J.
Shipping wt. 22 lbs.

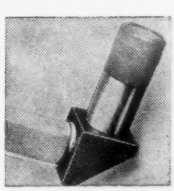
STANDARD 1¼" EYEPIECE HOLDER



Here is an economical plastic slide-focus eyepiece holder for 1¼" O.D. eyepieces. Unit includes 3"-long chrome-plated tube into which your eyepiece fits for focusing. Diagonal holder in illustration is extra and is not included.

Stock #60,067-Y . . . . . $2.50 ppd.

PRISM STAR DIAGONAL



For comfortable viewing of the stars near the zenith or high overhead with refracting telescopes using standard size (1¼" O.D.) eyepieces, or you can make an adapter for substandard refractors. Contains an excellent high-quality aluminized right-angle prism. The tubes are satin chrome-plated brass. Body is black wrinkle cast aluminum. Optical path of the system is about 3½".

Stock #70,077-Y . . . . . $12.00 ppd.

UNMOUNTED HERSCHEL WEDGE

Stock #30,265-Y . . . . . $3.50 ppd.

MOUNTED HERSCHEL WEDGE

Stock #30,266-Y . . . . . $5.50 ppd.

Sale! GIANT ERFLE EYEPIECE

Here is an exciting bargain. We have obtained a large lot of these eyepieces reasonably — so down goes the price to $9.95 for a real sale. Lens system contains 3 coated achromats over 2" in diameter. Gov't. cost over $100.00. Brand new, weight 2 pounds. The value will double when this lot is all sold, and triple and quadruple as years pass. If we didn't need to reduce our inventory, we'd be tempted to hold onto these eyepieces. Their wide apparent field is 65°. The focal length is 1½". Lenses are in a metal cell with spiral threads: focusing adapter with 32 threads per inch is included; diameter is 2-11/16". If you don't order now and you miss out on a hundred-dollar eyepiece for only $9.95, you can't say that we didn't try to impress you with its value. You can make some super-duper finders with these eyepieces. They are also ideal for rich-field telescopes, which are becoming more popular daily, particularly in the Sputnik age. Everyone with a large reflecting telescope should have one of these.

Stock #50,178-Y . . . . . Sale Price $9.95 ppd.

WAR SURPLUS! INFRARED SNOOPERSCOPE

Gov't. Cost $900 — Bargain at $39.50

Converts infrared to visible light. See in total darkness without being seen. Use in lab, factory, classroom, etc. Completely portable. Operates on two flashlight batteries (not included). Image is quite good, may be made even better by careful focusing. Size 11½" x 8". Weight with carrying case 12 lbs. No infrared light source is furnished (see below).

Stock #85,098-Y . . . . . $39.50 f.o.b. Barrington, N. J.

INFRARED LIGHT SOURCE AVAILABILITY!

You will need a 6-volt transformer or 6-volt auto battery to operate.

Stock #80,035-Y . . . . . $10.00 ppd.

6X FINDER TELESCOPE

Has crosshairs for exact locating. You focus by sliding objective mount in and out. Base fits any diameter tube — an important advantage. Has 3 centering screws for aligning with main telescope. 20-mm.-diameter objective. Weighs less than ½ pound.

Stock #50,121-Y . . . . . $8.00 ppd.

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Fantastic variety — never before have so many lenses, prisms, optical instruments, and components been offered from one source. Positively the greatest assembly of bargains in all America. Imported! War Surplus! Hundreds of other hard-to-get optical items. Many science and math learning and teaching aids. Write for Free Catalog "Y."

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The ideal coating for front surface **precision** mirrors for these reasons:

1. Beral has HIGH reflectivity.
2. Beral is HARD; does not sleek easily.
3. Beral can be cleaned easily — no porous OVERCOATING of quartz.
4. Beral is NOT a Chromium alloy, so can be removed easily.

Prices for Beral coating telescope mirrors: 3"-$2.25, 4"-$2.75, 5"-$3.00, 6"-$3.50, 7"-$4.00, 8"-$4.50, 9"-$5.50, 10"-$6.50, 11"-$8.50, 12½"-$9.75. Prices for sizes up to 37" diameter on request. Add Postage — Insurance for return mail.

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Reflecting Telescope Kits

Our kits have PYREX mirror blank, PYREX tool the same thickness, ample supply of optical quality abrasives, fast-polishing cerium oxide, red rouge and pitch. Packed in metal cans.

Size	*Thickness*	*Price*
4¼"	¾"	$ 6.00
6"	1"	$10.50
8"	1½"	$18.75
10"	1¾"	$33.65
12½"	2⅛"	$59.95

ADD POSTAGE: 1st and 2nd postal zones from Detroit, add 5%; 3rd and 4th, add 10%; 5th and 6th, add 15%; 7th and 8th, add 20%. Or we will ship C.O.D.

Send for free catalog of supplies, accessories, and refracting telescopes.

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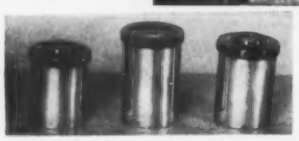
Guaranteed not to peel or blister.
Mirrors Made to Order — Mirrors Tested Free

EYEPIECES CELLS | **PRISMS BINOCULARS**

PRECISION TRI-TURRET

Holds 3 standard 1¼" O.D. eyepieces. Smooth turn to grooved notch aligns eyepiece precisely, ready to focus for various powers. Suitable for reflectors or refractors. **$15.75**



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HIGHEST QUALITY • MADE IN U.S.A.

Special four-element design, with fluoride-coated lenses, gives a wide flat corrected field. Standard 1¼" O.D. — E.F.L. 6-8-12-16-24-mm. ..... Postpaid **$15.95**

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GLEANINGS FOR ATM's

CONDUCTED BY ROBERT E. COX

A Herschelian Telescope for Lunar and Planetary Observing

SINCE READING Russell Porter's exciting description of the sun's image projected off-axis with a 100-foot focal length mirror (*Amateur Telescope Making — Book One*, Chapter 3), I have wanted to try this principle. The high powers obtainable without using a Barlow lens and the freedom from spider diffraction seemed an unbeatable combination for lunar and planetary observations.

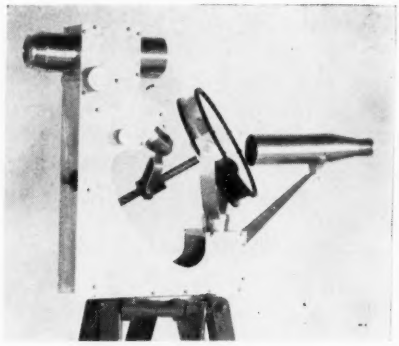
Not having 100 feet of space, and fearing that the images of planets at this focal length would be too dim, I decided to make a 6-inch of f/40. To my surprise the moon is uncomfortably bright with this Herschelian system, but views of planets and double stars are magnificent.

With a 240-inch focus, high powers are easily obtained. War-surplus Erfle eyepieces are ideal for use during average seeing conditions. Because an Erfle's lenses are of large diameter in proportion to its focal length, the field of view is actually greater than in a conventional 6-inch f/8 reflector at equal power.

Since the mirror sagitta is only 0.009", grinding was no problem. During the Foucault test, a small telescope was used to see the shadows on the mirror.

The large photograph shows the operation of the completed system. Light from the object is directed by the siderostat mirror (an 8-inch flat) to the spherical mirror at the far right, and back above the flat to the eyepiece. The focus is 20' from the spherical mirror, giving a generous 2¼" diameter to the moon's image.

It was some time before I learned the correct method of mounting and driving the flat equatorially. It must turn at half the diurnal rate, or once in 48 hours, to allow for both the angles of incidence and of reflection from the flat. Although the field of view rotates slowly as the drive runs, this has not inconvenienced me. Compare the siderostat with the one for the giant Paris telescope on page 509 of the August, 1958, Sky and Telescope.



The siderostat and eyepiece assembly with the finder telescope in position.

The finder is essential, as otherwise painstaking search is needed to bring a sky object into the narrow field of the long-focus telescope. The small photograph shows it in place in front of the flat; after an object is centered, the finder is removed to permit viewing through the 6-inch system.

A. W. LILGE
1336 Brampton Rd.
Los Angeles 41, Calif.

A. W. Lilge's Herschelian is mounted on high tripods to reduce temperature effects from ground currents during observing. Photographs by the author.

MAKING LONG-FOCUS MIRRORS

AFTER the article on my solar observatory was printed in last September's issue (page 593), a number of readers have asked me how long-focus mirrors, such as the f/56 of my solar telescope, are made. At such extreme focal ratios, the surface figure is made spherical, differing negligibly from a paraboloid.

Having some 25 years of optical experience, I am able to figure mirrors of extremely long focus by more or less conventional methods. The following procedure, however, is much easier, and gives a higher degree of precision from the outset. While mirrors of any focal ratio can be worked in the same fashion, let us consider a 6-inch blank that is to have a focal length of 300 inches or 25 feet. The f/50 telescope made with such a mirror can be used especially for lunar and planetary work.

The first step is to make a master. Procure two glass disks of 10″ or 12″ diameter, such as old tools. As the flat, back surfaces are to be worked together, it may be necessary to fasten a ring on the grinding barrel, so the lower disk, with its convex side down, will remain stationary. The two glasses are ground together with No. 80 carborundum in the ordinary way.

If the work is done outdoors, it is easy to determine the focal length on a sunny day. Clean the concave top disk, and douse it with kerosene to make it reflecting. Throw an image of the sun on a fence or wall in the shade, about 25′ away. Move the mirror to and from the wall until the image is sharpest, and the distance will be the focal length. Probably the solar image will be highly astigmatic and egg-shaped. If so, the proper distance is that which makes the image smallest.

When the radius of the master is nearly correct, clean the work barrel and disks carefully and continue the grinding with No. 320 carborundum. The two disks are to fit closely enough together so that no bubble pattern forms between them during working. This may be accomplished by grinding with one disk on top for a spell, then the other. This reversal is also a convenient way to shorten or lengthen the focus. Use the tool on top if the focal length is too short, underneath if it is too long. Avoid long strokes, as it is very easy to steepen the center or flatten the edge. When things are about right, clean up and check the evenness of the grind on the two disks. The familiar pencil-mark test may be made to find if the two surfaces coincide.

Next, a few wets of fine emery are used to smooth the surfaces of the disks, thereby making them better reflectors and allowing a more accurate determination of focal distance. The *convex tool* is now ready to be used as the master curve for the 6-inch mirror.

The 6-inch pyrex blank should have a molded face that is as flat as can be selected from stock. This should be specified in ordering it from the dealer. A ¼″-thick piece of plate glass, a foot or so square, is used with No. 320 carborundum to grind the face of the blank flat. The flatness may be tested by placing a steel straightedge across the disk and looking toward a light source. Try to work over all of this plate, occasionally overhanging the edges by nearly half a diameter, in this way keeping it flat. Should it become concave, which would make the 6-inch disk convex, turn the glass plate over and finish the grinding on the other side.

The blank now has a plane surface with no irregularities larger than the pits from No. 320 carborundum. The convex master is mounted on the work pedestal and grinding is begun with an ordinary starting emery. We do not need any coarser grit than this, for the mirror sagitta will be only 0.0075″. The appearance of the emery-worked surface is quite different from that ground with carborundum, making it easy for the operator to keep track of the concentricity of the curve being generated on the disk. Try to give all areas of the master the same amount of work.

Mirror rotation and the rate of travel around the pedestal should be rather uniform. The speed of the strokes should be somewhat slower than in conventional mirror making. Too fast a stroke will cause the pyrex disk to rock and to plow

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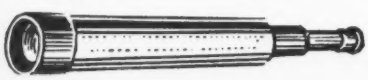

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7 x 50	372	American	32.50	—
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into the emery, thus grinding in a turned-down edge.

While the master will be only slightly worn by the emery, its surface will become somewhat flatter. If the final focal length is critical, the master tool should be made a little shorter than is desired for the finished mirror. The entire process will lengthen the focus slightly, probably by less than a foot for an f/50 mirror.

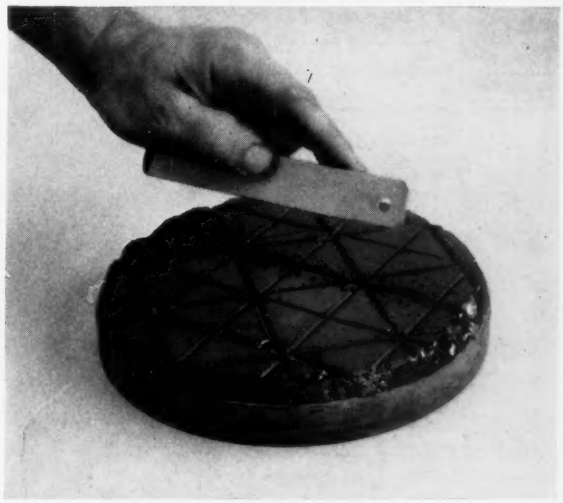
After all the carborundum pits have been removed, the worker can proceed through the fine grinding emeries until the surface is ready for polishing. If care is used, the spherical surface should be much more accurate than one made on a normal-sized tool, since we scaled down errors by having the work only $\frac{1}{3}$ or $\frac{1}{4}$ the area of the tool. A final "kerosene check" on the focal length is a good precaution at this point.

For the polishing lap, I strongly recommend a mixture of Stockholm pitch and pure white paraffin wax. This gives excellent control and performance, and I have used it for turning out hundreds of optical surfaces. To make the polisher, a 6-inch tool is fenced with masking tape or paper around its rim to form a well about $\frac{3}{8}$" deep. Tool and fence are dry-warmed while the mirror is heated in a pan of scalding water. In another pan, enough Stockholm pitch is placed to fill the well, and about $\frac{1}{3}$ of this amount of paraffin is added. Melt the two together and stir thoroughly, taking care that the mixture does not boil or bubble. Carefully level the tool, and pour in the lap mixture almost to the top of the fence.

Adding wax to the pitch does not necessarily make the lap softer, but it gives a clean-working surface that is much less sticky than pitch alone.

After the lap has cooled enough to stand up without the wall, strip off the tape and press the lap into shape with the warmed mirror face. Do *not* use rouge or soap to keep the lap from sticking, only warm water. Many failures in lap making can be traced to the use of soap or polishing agents during pressing. The foreign matter dries on the lap, causing "ties" by not allowing the pitch to flow under cold pressure. Matters become even worse when wax is applied over such a surface!

The next operation is channeling the lap. Rubber mats are not recommended, as they may later produce zones. Instead, when the lap is cool and fits the mirror as closely as possible, cut the channels with a coarse-toothed saw blade, such as a keyhole saw or a heavy hacksaw. Do not cut down to the glass, but leave a bottom to hold the lap together. Holding the saw



Cutting channels in a flat polishing lap with a heavy hacksaw blade. This mixture of tar and rosin does not cut as cleanly as the author's combination. Therefore, it is advisable to chill similar materials under cold water before cutting the grooves.

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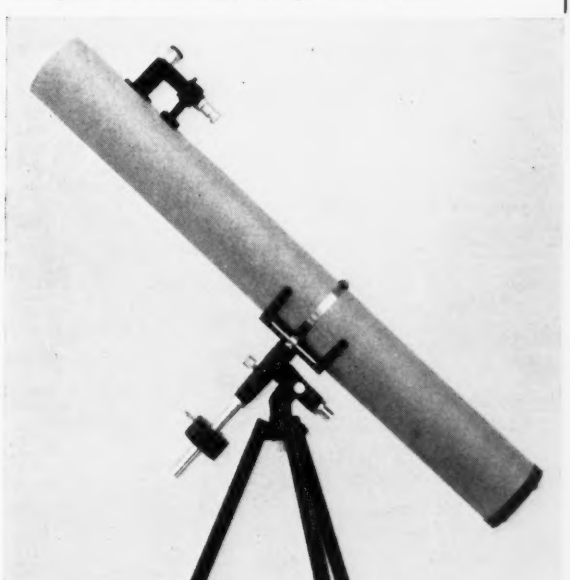

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at an angle will help prevent chipping, particularly at the start of a new cut. As the facets are being shaped, a soft and fluffy 1" paint brush is useful for removing the sawed pitch.

When the lap is clean and dry, more paraffin is melted, and a 1/16" coat applied with a brush to the surface of the lap, as evenly as possible. Let the channels fill; afterwards, running a beer-can opener down each channel will curl the wax smoothly away. Keeping all warm and wet, press the lap and clean it, repeating this until it is in good order. Only then can polishing agent be used.

To ensure good contact between the paraffin-coated lap and the blank, lightly wet the mirror face with white gasoline and rub it gently over the lap for a few minutes. Then rinse the lap with a sudsy solution of Tide in cool water, while lightly dressing the paraffin surface with a small, fairly stiff brush. Following this, give several hours of cold pressing.

For the polishing mixture, add a level teaspoonful of cerium oxide to a jelly glass of warm water, together with a little Tide detergent, stirring until frothy. Avoid liquid soap as it glazes the lap. Then put some of the thicker portion on the still-warm lap, and polish for five or 10 minutes to charge it. Every facet should show wear by becoming pinkish.

Polishing is rapid with a lap of this type, giving a velvety sheen to the mirror under the knife-edge test. It "charges" with a beautiful even color when, in the last stages of figuring, only water is used.

Testing the f/50 mirror by the knife-edge method will probably have to be done outdoors at night, because the mirror and knife-edge must be 50 feet apart. If unwanted lights are screened off, it is easy to locate the reflection of a flashlight from the mirror. The conventional pinhole does not give enough light, so the hole should be ⅛" in diameter.

After the Foucault test shows that the mirror appears quite spherical, a more refined check should be made with a smaller pinhole and a brighter light source. The amount of polishing required to remove a hill or bring up a hollow is surprisingly small in the last stages. Half a dozen strokes may be enough.

An f/50 6-inch mirror has interesting uses. Combined with a good flat, it makes a fine horizontal solar telescope. For studying the sun by projection, the optics may be aluminized, but for direct viewing they should be uncoated. A long-focus horizontal telescope can be very effective for lunar work, provided temperature differences in the light path can be overcome.

One plan for using mirrors of extreme focus is in a folded instrument. The mirror is attached to the lower end of a spar, and casts its converging beam to a smaller, off-axis flat at the upper end, to return the focus to a point alongside the primary.

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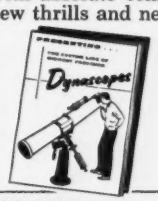

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The cells at the right on Edgar Everhart's telescope hold extra eyepieces.

PENTA-PRISM DIAGONAL FOR FINDER SCOPES

WHEN a small refractor is used as a finder on a Newtonian reflector, its field of view is rotated with respect to the main field, and it is awkward to use for zenith observing. Sometimes, also, the finder may be mounted too close to the telescope tube for an observer's eye to look through it conveniently.

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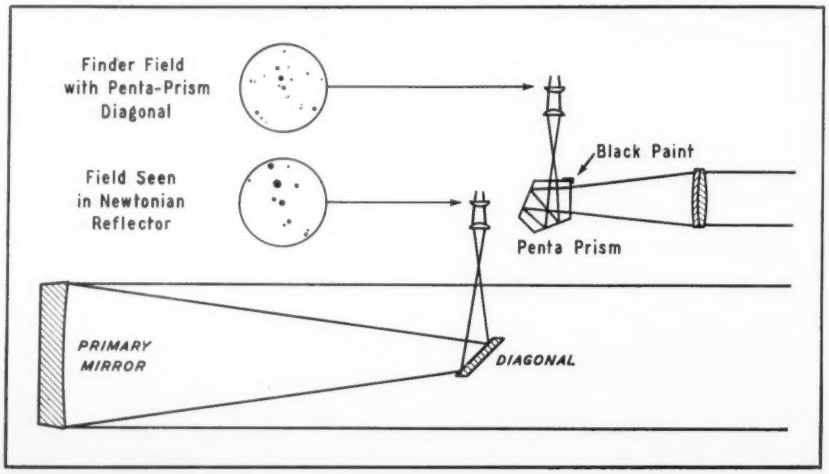
EDGAR EVERHART
Wormwood Hill
Mansfield Center, Conn.



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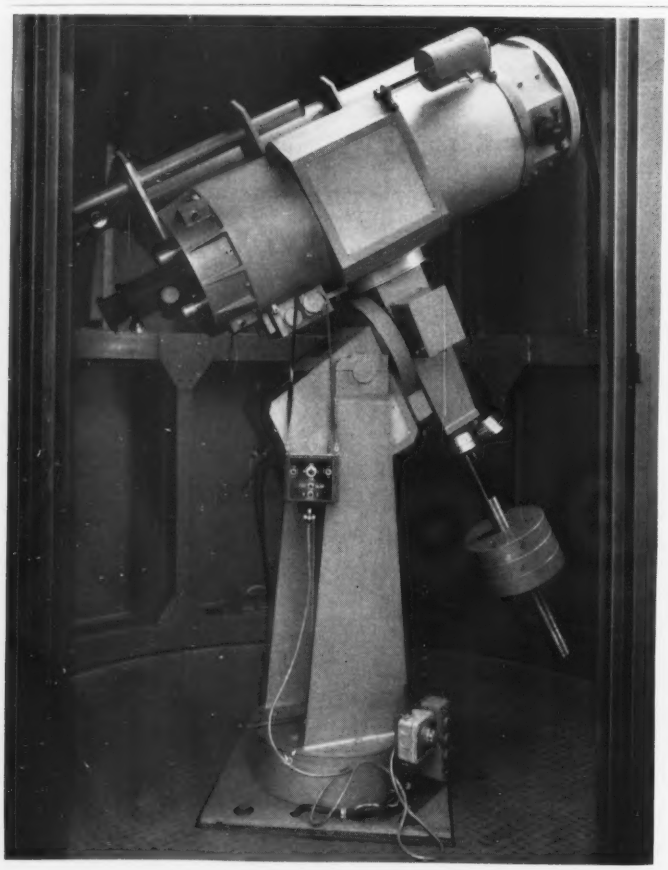

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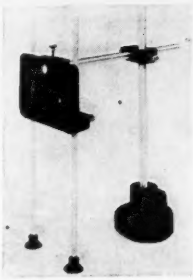

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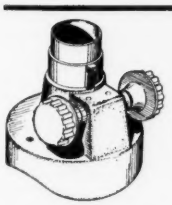

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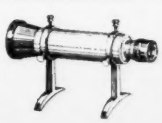

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CELESTIAL CALENDAR

Universal time (UT) is used unless otherwise noted.

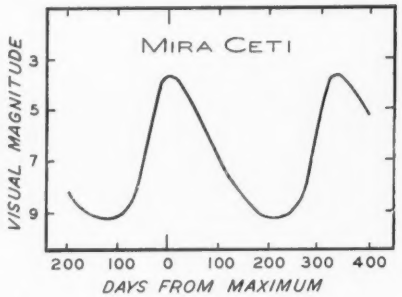
OMICRON CETI

MOST FAMOUS of all the long-period variable stars is Omicron Ceti, which reaches maximum light during the second half of this month, when it will be a naked-eye object in the morning sky. At an average maximum, this star attains magnitude 3.7, but sometimes it fails to rise above 5, while in 1779 it became almost as bright as Aldebaran.

Like all other variables of its type, o Ceti has an inconstant period. It averages 331 days, of which 118 are required for the rise from minimum light (usually magnitude 9). The accompanying mean light curve was derived by Leon Campbell from 10,956 estimates of brightness by members of the AAVSO.

The light variations of this star were noted as early as 1596 by the German amateur David Fabricius. About half a century later, the 11-month-cycle of its light variations was recognized, gaining for it the name Mira, the Wonderful.

Small amateur telescopes will show a 9th-magnitude star about 2′ east of Mira. Less than 1″ from the variable is a white-dwarf companion which was first seen in 1923 by R. G. Aitken with the 36-inch refractor. He gave credit for the discovery to A. H. Joy, who had already surmised the companion's existence from spectroscopic observations. This star is about magnitude 10, and also varies.



Average light variations of Mira, reproduced from "Studies of Long Period Variables," by Leon Campbell.

When bright, Mira is easily found with the unaided eye, not far from the head of Cetus the Whale. Continue a line from Alpha to Delta Ceti as far again. Mira's fine orange color is conspicuous in binoculars. Its spectral type is late *M*.

VARIABLE STAR MAXIMA

August 2, RT Cygni, 194048, 7.4; 7, S Herculis, 164715, 7.6; 11, R Phoenicis, 235150, 7.8; 12, W Lyrae, 181136, 8.0; 15, S Virginis, 132706, 7.1; 18, R Normae, 152849, 7.2; 21, Omicron Ceti, 021403, 3.7; 23, V Bootis, 142539, 7.9; 24, R Virginis, 123307, 6.9; 24, U Herculis, 162119, 7.6; 25, RS Herculis, 171723, 8.0; 27, X Ophiuchi, 183308, 6.9.

September 5, T Centauri, 133633, 6.1; 8, S Hydrae, 084803, 7.9; 9, W Andromedae, 021143, 7.5.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

AUGUST METEORS

The first-quarter moon will not seriously interfere with observations of the Perseid meteors this year. The shower will be visible for the first two weeks in August, reaching a maximum on the 12th, when a single observer may see as many as 50 meteors per hour. On the 12th the radiant will be located near the Cassiopeia-Perseus border, at right ascension 3^h 04^m, declination +58°, moving eastward by 1⅓° per day.

W. H. G.

MOON PHASES AND DISTANCE

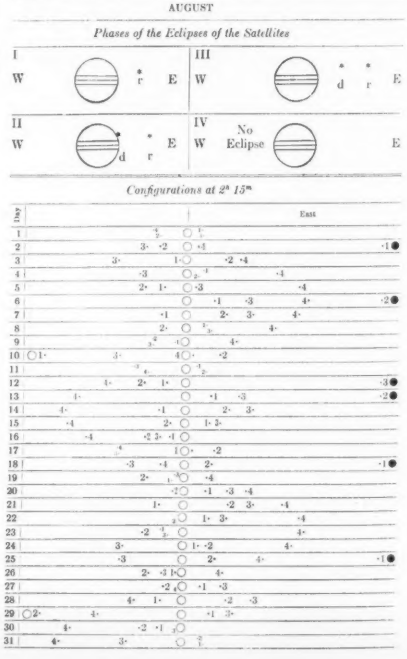
New moon	August	4, 14:34
First quarter	August	11, 17:10
Full moon	August	18, 12:50
Last quarter	August	26, 8:03
New moon	September	3, 1:55

	Distance	Diameter
August		
Perigee 13, 16^h	229,200 mi.	32′ 24″
Apogee 26, 6^h	251,200 mi.	29′ 34″
September		
Perigee 7, 17^h	229,100 mi.	32′ 25″

JUPITER'S SATELLITES

The configurations of Jupiter's four bright moons are shown below, as seen in an astronomical or inverting telescope, with north at the bottom and east at the right. In the upper part, *d* is the point of disappearance of the satellite in Jupiter's shadow; *r* is the point of reappearance.

In the lower section, the moons have the positions shown for the Universal time given. The motion of each satellite is from the dot toward the number designating it. Transits over Jupiter's disk are shown by open circles at the left, eclipses and occultations by black disks at the right. The chart is from *The American Ephemeris and Nautical Almanac*.



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12½″ REFLECTOR, complete with drive and accessories. Also 10″ f/6.5 and 6″ f/14.5 mirrors. Write Ronald Parmentier, 113 E. Walnut St., Green Bay, Wis.

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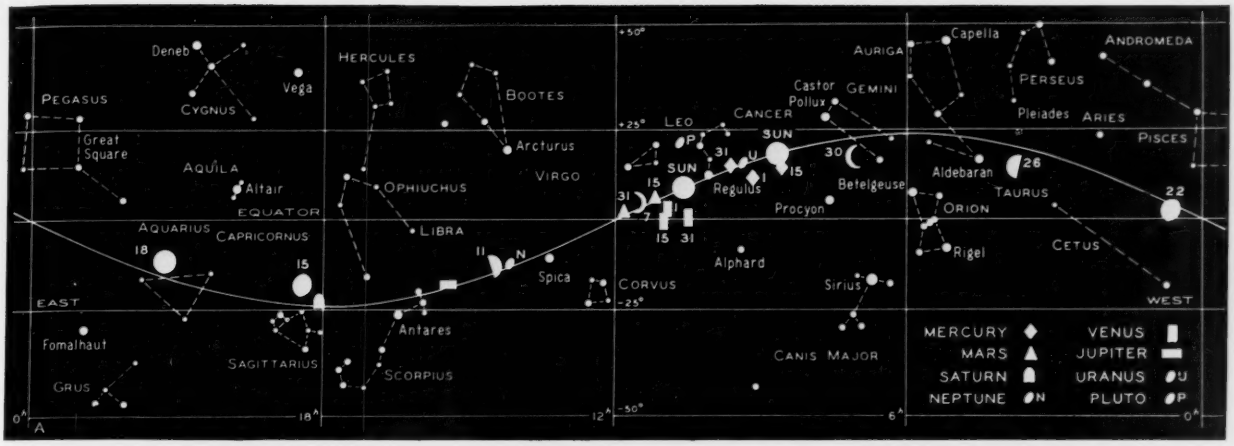

THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other days shown. All positions are for 0^h Universal time on the respective dates.

Mercury cannot be seen during the first part of August, as it reaches inferior conjunction on the 5th. It then rapidly moves to greatest western elongation, 18° 25′ from the sun, on the 23rd, when it is visible in morning twilight, rising about 1½ hours before the sun. Mercury will be well placed in the sky for observation for about a week before and after the 23rd. On that date a telescope will show it as a disk almost at quarter phase, about 40-per-cent illuminated and 7″.5 in diameter. It is then of magnitude +0.1.

Venus is a bright evening object, low in the west after sunset on August 1st. It rapidly approaches the sun, and by mid-month is too near it to be seen. The thin crescent moon will pass 3° north of Venus on the evening of the 6th. The planet is then magnitude −4.1, its slender crescent only 17-per-cent illuminated and 45″.3 in diameter.

Mars sets too soon after the sun to be visible this month.

Jupiter is at eastern quadrature on August 16th, a brilliant yellow object in Libra, magnitude −1.7. It is in the southwest after sunset, where it sets about an hour before midnight, local time. A telescope will reveal its slightly flattened disk, 38″ in equatorial diameter and 35″ in polar. The moon will be only about 3° north of Jupiter on the evening of the 11th.

Saturn crosses the meridian about 1½ hours after sunset in the middle of the month, and is visible in Sagittarius in the southwestern sky as an object of magnitude +0.5. It sets about an hour after midnight, local time. The rings, 40″ across this month, are easily seen in a telescope, and the planet's disk is 15″.9 in polar diameter. The moon will pass 4⅓° north of Saturn during daylight on August 14th.

Uranus is in conjunction with the sun on the 10th, and is near it all month.

Neptune on the 15th is in eastern Virgo, at right ascension 14^h 10^m.5, declination −11° 18′ (1950 co-ordinates), and is visible low in the southwest for a while after sunset. Its tiny greenish disk is 2″.4 in diameter, recognizable in large amateur telescopes.

W. H. G.

UNIVERSAL TIME (UT)

TIMES used in Celestial Calendar are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. To obtain daylight saving time subtract 4, 5, 6, or 7 hours, respectively. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown. For example, 6:15 UT on the 15th of the month corresponds to 1:15 a.m. EST on the 15th, and to 10:15 p.m. PST on the 14th.

MINOR PLANET PREDICTIONS

Eunomia, 15, 7.8. August 10, 23:14.5 +9-49; 20, 23:08.4 +10-40; 30, 23:00.1 +11-07. September 9, 22:50.7 +11-11; 19, 22:41.4 +10-54; 29, 22:33.6 +10-18. Opposition on September 5.

Ariadne, 43, 9.6. August 30, 0:04.3 +7-32. September 9, 23:55.9 +6-51; 19, 23:46.2 +5-51; 29, 23:36.8 +4-41. October 9, 23:29.0 +3-32; 19, 23:23.8 +2-36. Opposition on September 19.

Fortuna, 19, 8.9. August 30, 0:12.1 +3-15. September 9, 0:06.2 +2-33; 19, 23:58.4 +1-35; 29, 23:50.1 +0-32. October 9, 23:42.5 −0-29; 19, 23:36.9 −1-19. Opposition on September 22.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0^h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

MINIMA OF ALGOL

August 3, 20:04; 6, 16:53; 9, 13:42; 12, 10:30; 15, 7:18; 18, 4:07; 21, 0:56; 23, 21:44; 26, 18:33; 29, 15:21.

September 1, 12:10; 4, 8:59; 7, 5:47.

These minima predictions for Algol are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.

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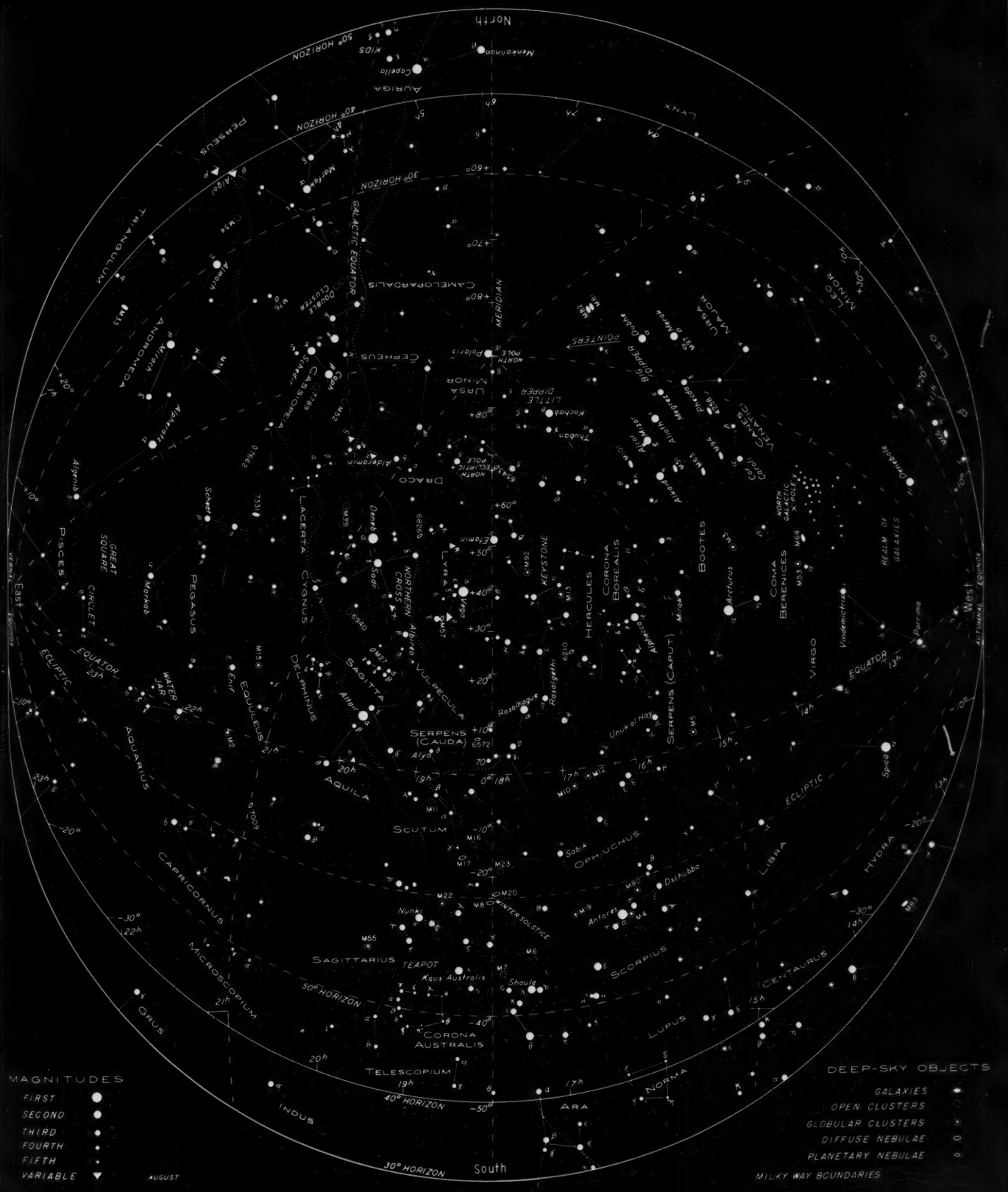
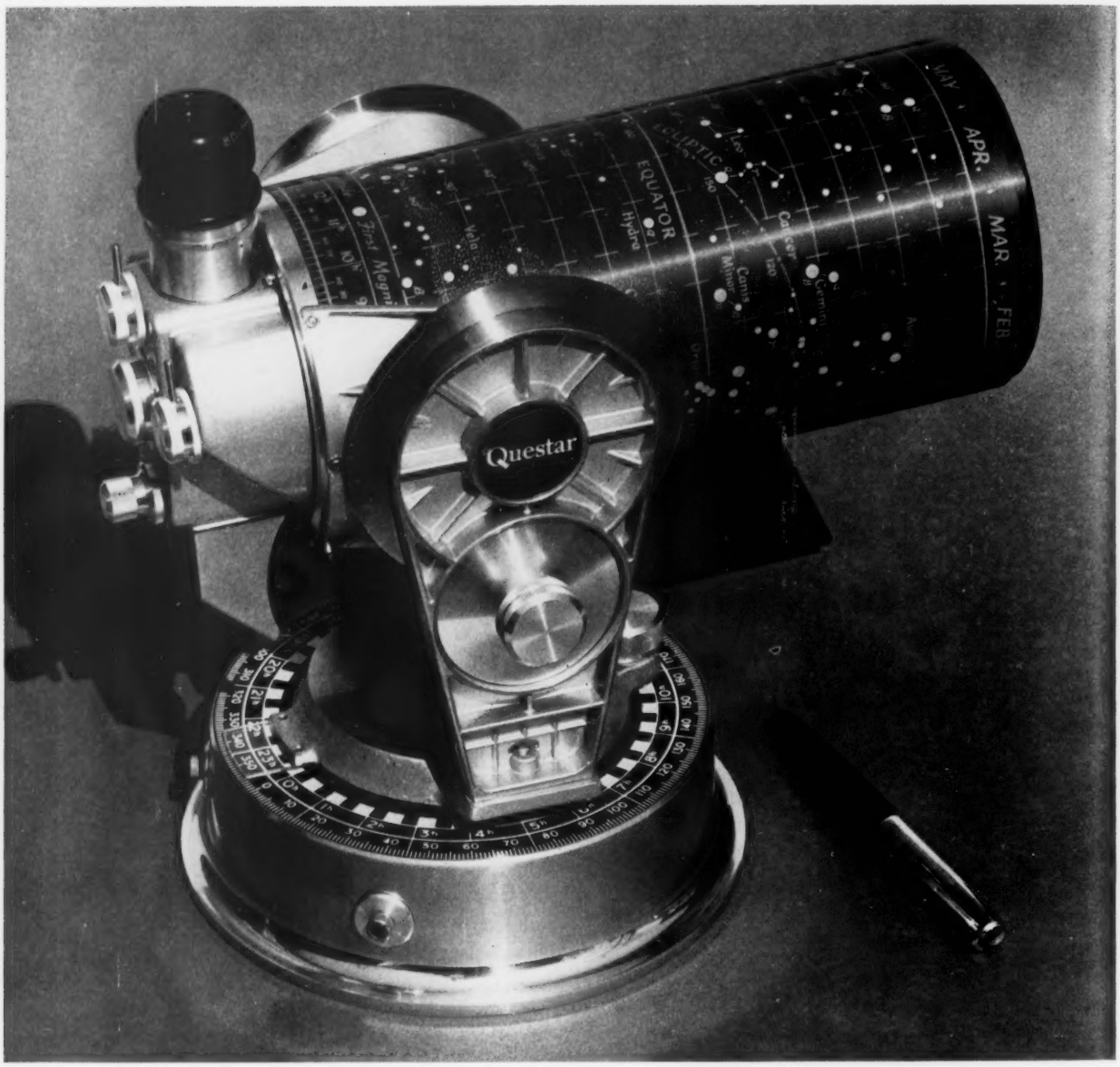


STARS FOR AUGUST

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 22nd of August, respectively; also, at 7 p.m. on September 7th. For other dates, add or subtract ½ hour per week.

Toward the south this month the sky is particularly rich in stars. Against the background of the Milky Way are seen Scorpius, now past the meridian, and the easily recognized Teapot of Sagittarius. These constellations well merit viewing with binoculars on a dark night.



"I have a larger telescope, but the inconvenience of setting it up makes Questar the one I use most of the time."

— Luis L. Osuna, Avenal, California

That is a nice simple statement, isn't it? Puts the matter in a nutshell, so to speak. But there is more to the story. Over a year ago Mr. Osuna wrote us to say that he wanted to send his Questar back for a checkup, since it seemed suddenly to have lost some of its efficiency. We said, fine, just put it back into the shock-absorbing Leverpak drum, mail it to us, and when it gets here we will tell you what we find.

Then nothing happened for the next eleven months. Absolutely nothing. Finally, in May he sent the instrument to us, and at once we located the trouble — the prism was quite askew in its clamp, which made the whole instrument seem badly out of line. We wrote him about it, which elicited the letter from which we are quoting.

"It is surprising how much I miss the Questar, which is one reason I delayed so long in sending it back. I have a larger telescope, but the inconvenience of setting it up makes Questar the one I use most of the time."

We think this is an interesting comment, but we find Mr. Osuna's actions even more interesting than his words. For here is a man who apparently has become so fond of using an instrument, night after night, that he postpones sending it back for almost a year. He knows that something is a little off, but he hates to do without his favorite telescope long enough to have it fixed.

We think this is wonderful consumer acceptance. And we also think we understand the situation a little. Do we not all get attached to a certain coat, or shirt, or suit of clothes, or pair of shoes, and then persist in wearing this most comfortable thing as much as possible? This is what happens to many Questar owners. They fall in love with the instrument, and they use it all the time.

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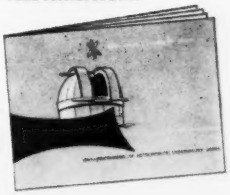

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See pages 570 and 571.

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